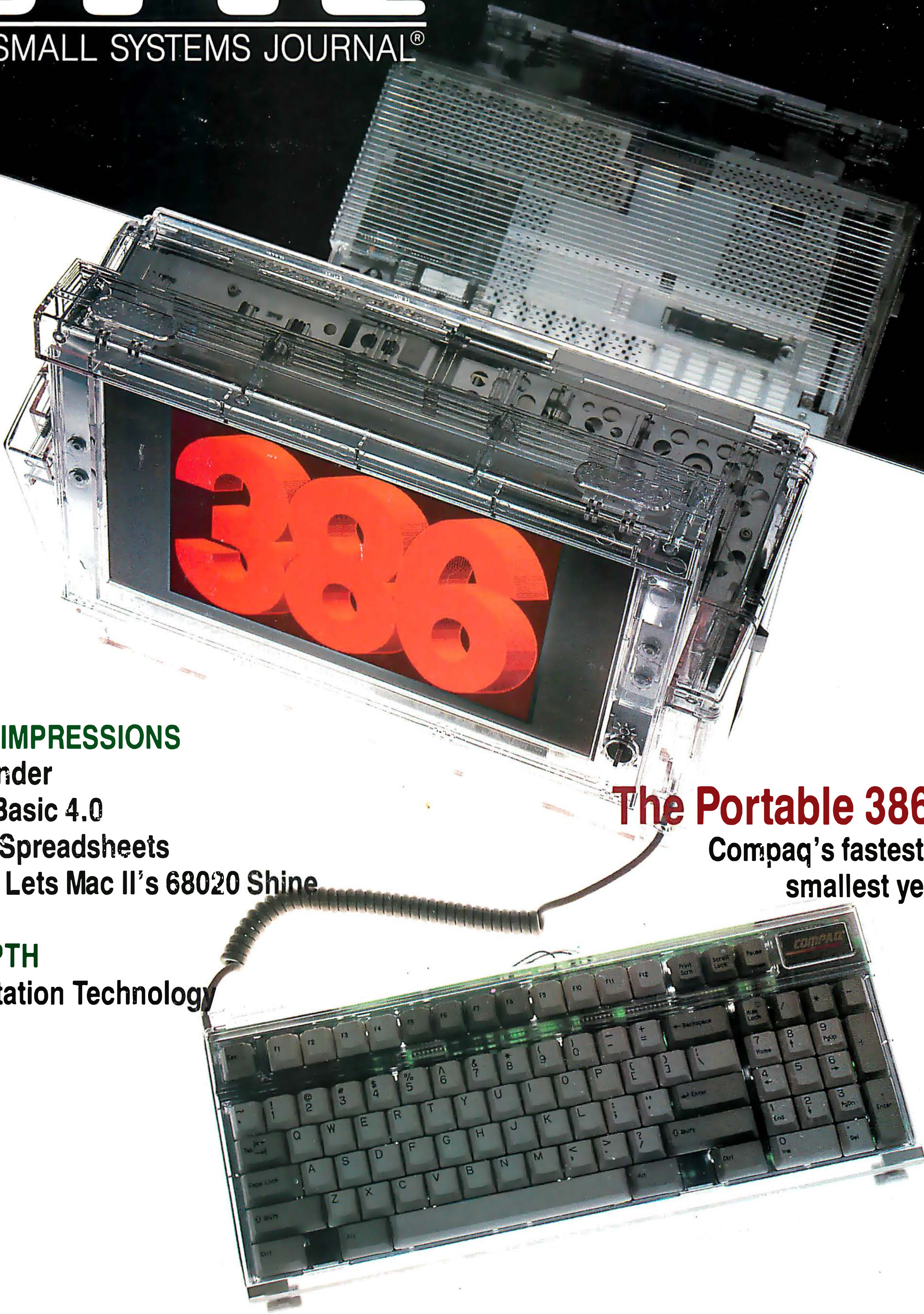
BYTE

THE SMALL SYSTEMS JOURNAL®

NOVEMBER 1987 VOL.12, NO.13

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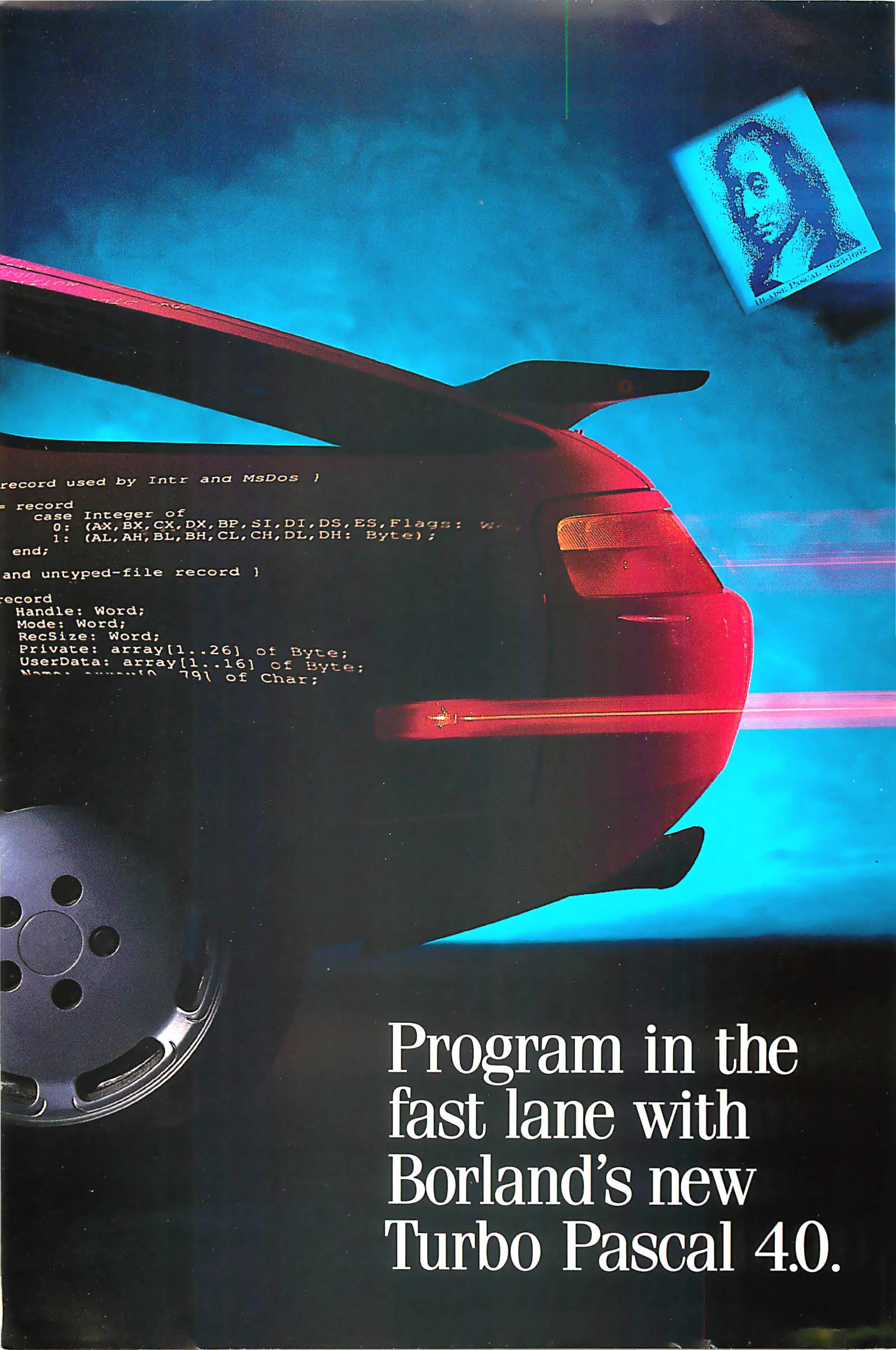
Multifinder
QuickBasic 4.0
3 New Spreadsheets
MPWC Lets Mac II's 68020 Shine

IN DEPTH

Workstation Technology

The Portable 386

Compaq's fastest, smallest yet



BLAISE PASCAL 1623-1662
record used by Intr and MsDos }
= record
case Integer of
0: (AX,BX,CX,DX,BP,SI,DI,DS,ES,Flags:
1: (AL,AH,BL,BH,CL,CH,DL,DH: Byte);
end;
and untyped-file record }
record
Handle: Word;
Mode: Word;
RecSize: Word;
Private: array[1..26] of Byte;
UserData: array[1..16] of Byte;
of Char;
Program in the fast lane with Borland's new Turbo Pascal 4.0.

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4.0's cursor automatically lands on any trouble spot

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4.0 gives you an integrated programming environment

4.0's integrated environment includes pull-down menus and a built-in editor. Your program output is automatically saved and shown in the output window. You can Scroll, Pan, or Page through all your output and know where everything is all the time. Given 4.0's integration, you can edit, compile, find and correct errors—all from inside the integrated development environment.

You'll never lose your mind, because 4.0 never loses your place

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*Run on an 8 MHz IBM AT.

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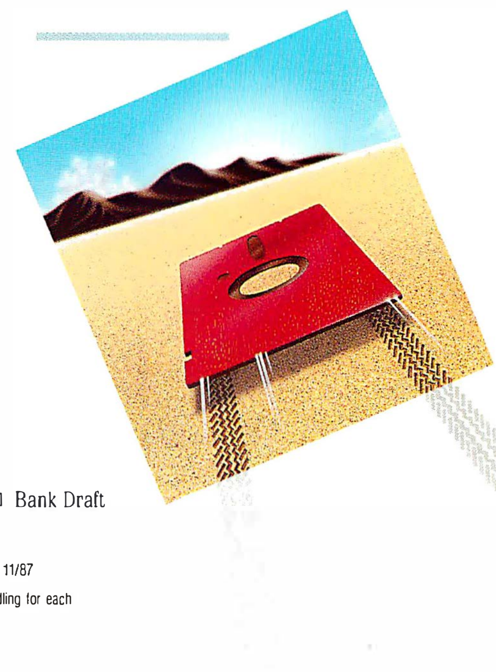
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VOLUME 12
NUMBER 13

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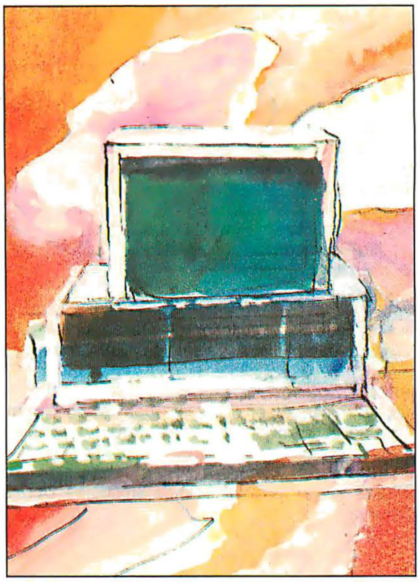


The Compaq Portable 386

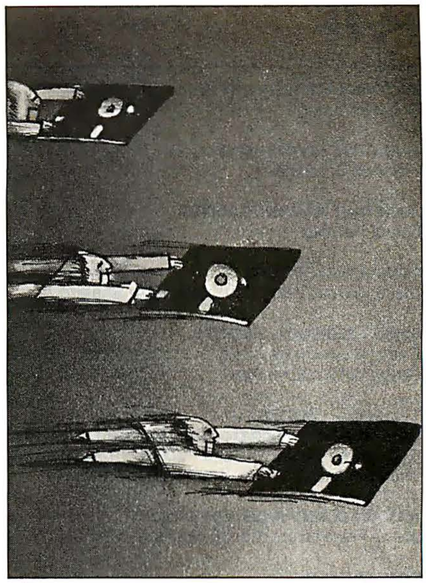
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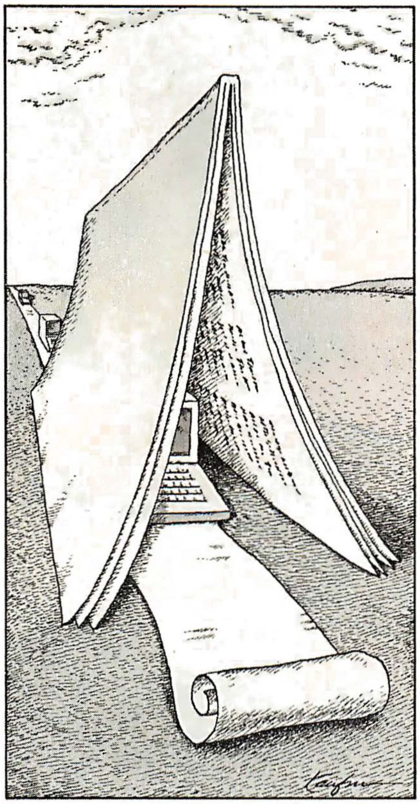
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EDITORIAL



BYTE Gets Ready for 1988

This month, we introduce a new and reorganized BYTE, which will feature two major changes. First, we are grouping most product-related articles in a huge new section called Products in Perspective. Second, we are spinning off the former Best of BIX section into four much larger machine-specific supplements to BYTE.

We are excited about these changes because they will enable us to bring you a richer variety of product information and more individualized information about your favorite machine or machines, without compromising our traditional depth.

Products in Perspective

This section examines the wealth and variety of microcomputer products from several different perspectives, including those of the news editor, the technical editor, the columnist, the highly qualified outside reviewer, and the sophisticated BIX user.

What's New includes short items based on product announcements. Each issue will also have several Short Takes, a new category enabling editors to share their hands-on experience with a new product without undertaking a full-scale review. First Impressions includes longer, more in-depth descriptions of major new products, much in the manner of our former Product Previews and Product Descriptions.

Next comes a generous selection of product reviews—new systems, new peripherals, new programming products, and new applications programs—with some enhancements. Some reviews of individual products will contain BIX user comments made when the review was posted on BIX before publication. These comments help answer the most frequent criticism of reviews—that they are just one person's opinion.

Starting with this issue, we will include a large Group Review each month, a look at a group of products of one type. This will be accompanied by the month's BIX Product Focus, a selection of comments from the sophisticated computer users of BIX on the same type of product. Together, these two articles will give each issue its main product focus.

Each Products in Perspective section will conclude with the insightful columns of Jerry Pournelle and Ezra Shapiro. Jerry covers a wide assortment of hardware and software. Ezra's column investigates applications software.

In Depth

The next section, In Depth, supplants the old Theme section as the place in which BYTE gives an in-depth look at one important topic each month. Possible topics include such major subjects as specific programming languages, optical storage, computer graphics, operating systems, simulations, telecommunications, artificial intelligence, and many more. The In Depth section also includes a list of resources, including products, related to the month's topic.

Features

The Features section provides articles on a variety of topics in each issue. Steve Ciarcia's hardware projects, which always include a tutorial in the relevant technology, will continue as a mainstay of this section. There will also be looks at innovative applications, new technology, programming techniques, algorithms, and many other topics. Major articles about new products will, however, appear in Products in Perspective rather than here.

BIX Highlights Expanded, Moved

You might say that we are moving BIX material outside the narrow confines of the Best of BIX. Although this section is disappearing, information from BIX will still be found in every issue of BYTE. Some of it will appear regularly in the BIX Product Focus. We will also draw on BIX for contributions elsewhere in BYTE.

The original intention of Best of BIX was as a temporary section from which we would spin off machine-specific supplements. And this time has finally come. Starting in January, you will be able to order highlights of the month's activity in some of the major conferences. Rather than getting only 2 to 4 pages on a specific machine each month, you will get 32 pages or more on your machine of choice. You will be able to get these expanded conference highlights in more than one way.

First, and available immediately, we are putting BIX conference highlights on the listings disks we already sell. If you order the listings on a Mac disk, for example, we will include at least 32 pages of Mac conference highlights along with the listings. This is true for other types of disks as well. The listings disks will keep the same prices they have now—$8.95 to $9.95 per month, or $69.95 to $79.95 per year.

Second, starting in January, we will supply highlights from BIX in print each month. These can be ordered separately, as the Listings Supplement is now. The pricing hasn't been set for these.

A More Representative Reader Poll

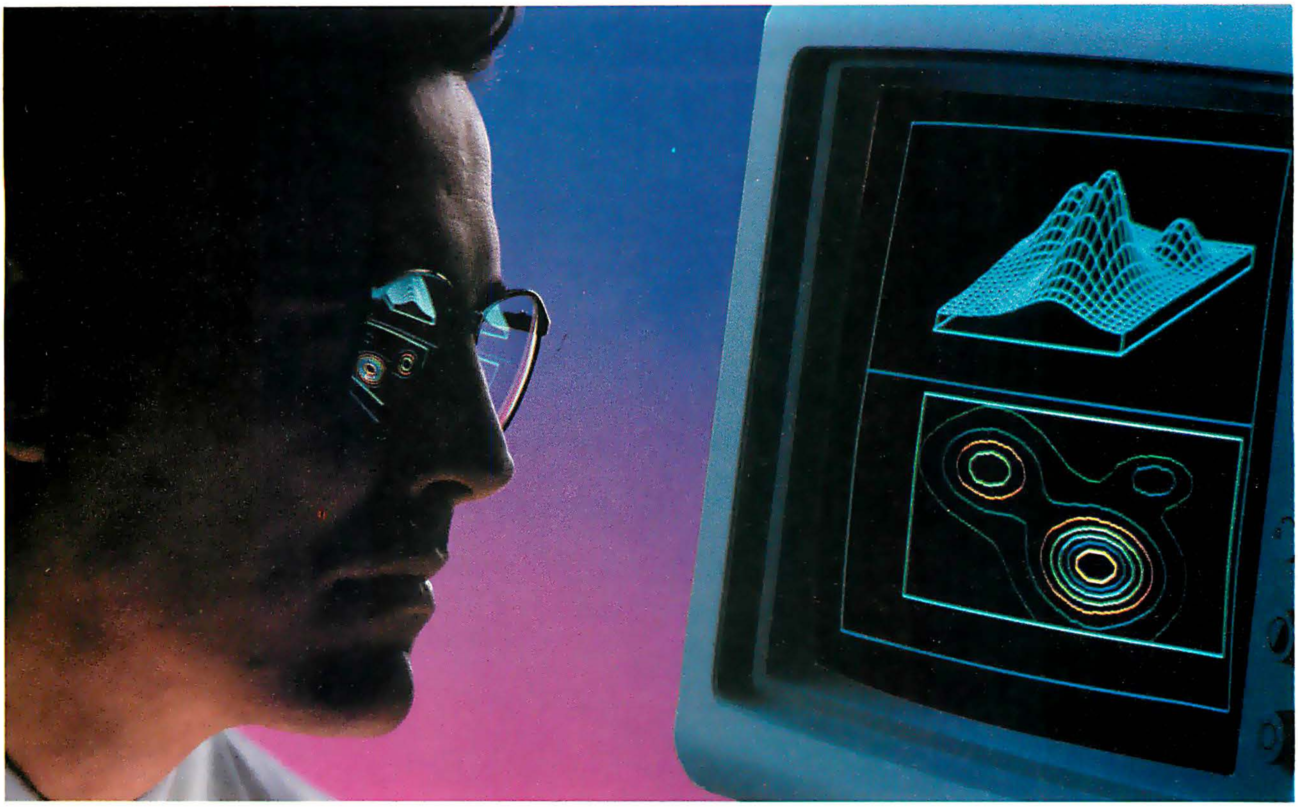
We are replacing the BOMB, BYTE's ongoing monitor box, with a random-sample survey of readers' opinions each month. We'll ask readers to rate the articles in each issue, rather than relying on the self-selecting sample that voted in the BOMB. We still want to hear from everyone who wishes to express an opinion and will continue to read with care all letters to the editor. If you're selected in the random sample, we hope you'll take the time to give us your candid opinions.

We hope you will like these changes and that they will help us better meet your needs.

—Phil Lemmons
Editor in Chief
(BIX name "plemmons")

Illustration by Robert Kaufman

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MICROBYTES

Staff-written highlights of developments in technology and the microcomputer industry.

Tape-Access Technique Takes the Fast Track to the Right Track

Scientific Micro Systems (Mountain View, CA) has developed a new technology that allows direct access to data stored on tape. The company claims Direct Tape Access (DTA) will speed up access times by as much as 70 percent compared to access when DTA is not used. In a demonstration for Microbytes, a sample tape-to-hard-disk restore operation of approximately 30 megabytes of data (consisting primarily of dBASE and WordPerfect files) took 8:01 minutes when DTA wasn't used. With DTA enabled, restoring the same data took 2:24. The demonstration was done on an IBM PS/2 Model 30 and an Identica 60-megabyte tape drive. SMS product manager Rick Luttrall was quick to note that DTA doesn't really improve tape-drive performance; it just shortens the time it takes to get to specified information. The maximum tape-drive data-transfer rate is 5 megabytes per minute.

DTA, described by Luttrall as a "software formatter," is implemented on an add-in controller card and associated software. Unlike conventional "hardware-formatter" tape-drive controllers, the SMS controller card does not have its own microprocessor. Instead, the DTA software completely takes over the PC's CPU during tape-drive access and executes at CPU rates. A DTA controller card itself is standard in that it handles interfacing and protocol conversion by taking the PC bus and converting data to QIC format (a standard set by the Quarter-Inch Tape Committee).

The software used with the DTA board lets users specify precise volumes or disks to restore from tape (tape directories can be displayed on the screen), since the software immediately locates the exact track where a backup session started or ended. In addition to incorporating special data-location algorithms, the software is optimized for specific microprocessor structures—clock rate, wait states, and so forth. (The type of PC is identified during the installation session.)

"DTA goes directly to the desired data," Luttrall said. "It doesn't look at data it doesn't need." You can also restore or save data from within application programs via execution of DOS command lines. With conventional tape systems, data is stored sequentially; if you want to access file 150, for instance, the system must read through files 1 through 149 first. With DTA enabled, you can go directly to file 150.

Initially, DTA will be implemented on SMS's new Identica 40-megabyte tape drive and on existing Identica 60- and 125-megabyte tape drives. The new internal 40-megabyte Personal Tape System will be available for the IBM PC AT and PS/2 for $599 and $699, respectively. SMS will make DTA technology available on an OEM basis.

Beware the Low-Grade Printer Ribbon, Repair Shop Says

Poor-quality replacement ribbons for dot-matrix printers cause about 80 percent of all printer problems, according to Icon Computer Corp (Tustin, CA), which specializes in repair of personal computers and peripherals. That's what Icon's repair data shows after thousands of service calls.

"It's very tempting to put in a ribbon that costs a third the price of a factory replacement," said Phil Kohler, president of Icon, "but in the long run, the odds are that you'll lose any savings because of repairs to the print head, drive mechanism, or electronics."

Kohler and Brad Pantoskey, vice president of marketing at Icon, told Microbytes that many inexpensive ribbons cost considerably less than OEM ribbons because they use different materials. Some plastic cases are

continued

Nanobytes

First, some notes from the Let's Get Militant Department. . . . It's time to give control of data back to the users, we heard former Apple "software evangelist" **Guy Kawasaki** tell a Boston audience recently. Three companies—IBM, Apple, and Microsoft—"control what you can do with your computer," Kawasaki said. "I think that's wrong." Users need "nonprogrammer" access to ROMs and a language that lets them easily build fancy applications, he said. Kawasaki cited the Mac telecommunications package **MicroPhone**, which lets you customize your communications package by using scripts, as "an example of how software should evolve.". . . At the same conference, we heard an executive from a big software house espouse self-described **"heretical" views** not friendly toward **OS/2**. He protested developers being pressured to write for that operating system. "We have to support this brain-damaged chip [the 80286] for now and forever. And the overhead [to do this] is enormous. Why couldn't IBM just make a hardware retrofit to a 386 and for all the computers out there and make an OS/386 that would allow a true presentation manager?" He said programmers "can't write true 32-bit code for OS/2 because it trashes the top 16 bits. We're writing for OS/2 to cover our bets.". . . A few weeks later and on the opposite coast, Microsoft chairman **William Gates** wrote off skeptics of OS/2 and the 80386 as the same people who didn't want to switch from CP/M to MS-DOS. As for other operating systems competing with OS/2 because of new multitasking software, Gates told the Silicon Valley User's Society,

continued

"Nobody should confuse the true multitasking of OS/2 with task-switching, which is what you basically get with DESQview or even Apple's MultiFinder."... The TransLink board from **Levco** (San Diego, CA) puts Inmos Transputer chips (either the T414 integer processor or the T800 floating-point processor running at 15 or 20 megahertz) inside a Macintosh II or SE. Each card that plugs into the Mac II's NuBus slot can hold as many as four Transputers, which means that box can be fitted with up to 20 of the powerful processors. The SE package starts at less than $2000, the Mac II version at less than $2500.... **Atari UK** has commissioned **Perihelion Hardware Ltd.** (Cambridge, U.K.) to develop an experimental coprocessor based on the **Transputer,** sources tell Microbytes. Perihelion will work on an add-on box for the **Mega ST** that contains a T414 chip. Specs call for a high-performance graphics subsystem, with 1024- by 768-pixel resolution and a palette of 4096 colors. Drawing will be hardware-assisted by a custom blitter array. No official word from Atari on when such a machine might make it to the market.... Meanwhile, **Perihelion Software Ltd.** (Shepton Mallet, Somerset, U.K.) is at work on a new operating system for the Transputer. Called Helios, it will be a true distributed operating system, in which the kernel resides on each Transputer in a system. Helios will be a message-passing system, using the chip's hardware links as message channels, according to a programmer working on the project.... **Graphic Software Systems** (Beaverton, OR) is going to bring the portable Open Dialogue user-interface manager from **Apollo Computer** (Chelmsford, MA) to the world of 80386 machines. GSS will port Open Dialogue to its version of X Window, GSS X/386. The companies claim this agreement will make Open Dialogue a standard for designing interfaces for applications running on everything from IBM PCs to workstations.... And now a

continued

thinner and can warp as the print head heats up, they said. When a case warps, it can bind and strain the drive mechanism, stripping gears or overheating a drive motor. Ribbon materials sometimes don't contain enough lubricant and cleansing agent, the lack of which can cause the print head to clog. When a pin can't move, there's a chance that the driving electronics can be damaged, they said.

Icon is an authorized repair facility for IBM, Epson, Compaq, Okidata, and Hewlett-Packard. With regard to the reliability of the microcomputers that Icon services, Kohler and Pantoskey said that today's systems are very competitive from a maintenance standpoint. The systems are "very reliable," with few problems like those with the CMI hard disk drives that plagued the IBM PC AT when it was introduced. Because of the disks' electromechanical construction, drive alignment and spindle speed are two things that should be checked regularly, Kohler noted.

Unix Workstations "Driving" IBM

Engineers "will all have the equivalent of a Cray-1 on their desks within this decade," IBM Fellow Andrew Heller told the American Society of Mechanical Engineers at its recent Computers in Engineering conference in New York City. Citing dramatic cuts in costs of memory and processing power and the increasing speed of graphics processing, Heller said that "workstations are the most explosive part of the computer industry."

"The Unix workstation platform is driving many of our decisions at IBM," said Heller, who is also vice president of advanced engineering systems at IBM. He pointed out that IBM's Scientific Division has been moved to the Entry Systems Division to accelerate the porting of IBM's Unix operating system, AIX, to the PS/2 Model 80. "The PS/2 is an important part of our product line," said Heller, "but visibly slower" than the desktop systems that will appear later in this decade. (IBM did not display PS/2s at the conference but emphasized its 3090 supercomputer processing family.)

Heller said there are "three truly exciting" developments in computer architecture: RISC, vector processing, and multiprocessing. He projected that "between 1985 and 1990, the price per megaflop will drop by a factor of 100," and clock speeds will approach 75 megahertz on CMOS processors, 500 MHz on ECL processors, and 3 gigahertz on GaAs processors. Distributed systems with centralized data access will no longer be a feature but a requirement in workstation systems, and they'll be used to design software so that data-intensive parts of a program can be executed separately from screen-intensive parts, allowing applications to transcend machine boundaries. "Engineers won't need balsa wood or clay anymore. You'll be able to visualize, design, and develop a model directly on the computer."

Fattened Memory Spec Beefs Up DOS, but OS/2 It's Not

When Intel, Lotus, and Microsoft announced the new version of the LIM Expanded Memory Specification, they took a step that could add years to the life of old MS-DOS. LIM EMS 4.0, a significant revision of EMS 3.2, allows multiple applications to run simultaneously in expanded memory and includes the capability to execute program code in expanded memory. Those features were originally developed by AST Research for the AST/Ashton-Tate/Quadram Enhanced Expanded Memory Specification (EEMS). AST Research said it would support EMS 4.0, thereby unifying the two specs.

The new spec stretches the expanded memory limit from 8 to 32 megabytes. Other features include multiple page-mapping, dynamic memory allocation, naming of data handles, and "far jump" and "far call" simulation. Rob Shostak, who helped develop Ansa's Paradox, said the far calls and jumps are significant, "because you can now write programs that reside in expanded memory and don't have to rely on overlay mechanisms that reside on disk."

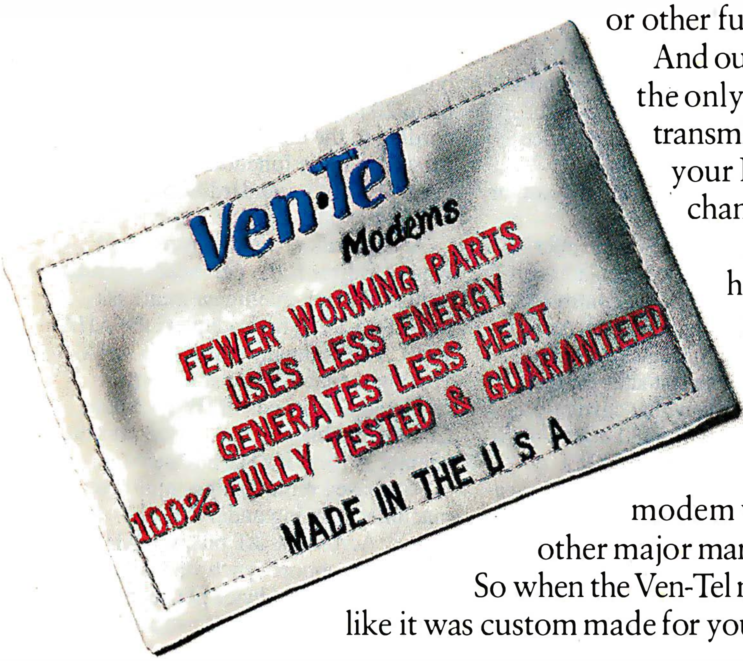
EMS 4.0 includes over 40 new functions and subfunctions for software developers and greatly increases the flexibility of expanded-memory applications. Current software applications running under EMS 3.2 or EEMS are upwardly compatible with EMS 4.0, but they will have to be redesigned to

continued

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report on what we remember seeing at **MacWorld Expo** in Boston: long lines, big crowds, big monitors, more big monitors, lots of upgrades, T-shirts saying IBM (I Bought Macintosh), and a sign promoting "multiuser desktop accounting" that prompted one observer to inquire as to other locations, besides the top of a desk, where accounting might be done. . . . Happy Anniversary to the **Intel 4004**, generally considered the first microprocessor. The chip made its commercial introduction 16 years ago this month.

take full advantage of 4.0's new features.

What does EMS 4.0 mean to those who are considering the forthcoming OS/2? Although EMS 4.0 allows more powerful applications to run under DOS, it is not an even swap for OS/2. In contrast to the large linear-address space of OS/2, EMS uses small portions (64K bytes) of memory at a time. To use an analogy provided by Shostak, you can think of EMS as providing a "small window on a sea of memory. You can use only one window at a time [64K bytes per window]." According to Shostak, "EMS is great for spreadsheet applications, because they don't require a lot of code space."

David Reed of Lotus Development Corp. said Lotus 1-2-3 Release 3 (scheduled for shipment in the first quarter of 1988) will support both EMS 4.0 and OS/2. "Seven million Lotus users can turn to EMS 4.0 and good old DOS 3 and get all the new features of Lotus Release 3 running under OS/2," said Reed.

For large programs requiring a large address space, however, performance would be very slow using expanded memory. Steve Ballmer of Microsoft said that "OS/2 provides a uniform address space and interface features that will never be duplicated by MS-DOS." Robert Carr, chief scientist at Ashton-Tate, agreed, saying that his company is taking a "high-fork and low-fork strategy. On the low fork (MS-DOS), we'll provide a consistency of user interface and data exchange, but many of the high-technology features of OS/2 won't be available on MS-DOS."

Controller Chips Add More Zip to SCSI

In an effort to squeeze greater performance from microcomputer devices that use SCSI I/O ports, Logic Devices (Sunnyvale, CA) and Adaptec (Milpitas, CA) have developed high-performance SCSI controller chips that can more than double current data-transfer rates. While common SCSI data transfers are generally considered to be from 800K bytes per second to about 1.5 megabytes per second, the new generation of controllers will increase data transfers to as much as 4 or 5 megabytes per second.

"SCSI is about to explode," Logic Devices spokesperson Joel Dedrick told Microbytes, "and workstations will be the key because they need performance. As companies like Apple try to milk higher performance out of computers like the Mac, data-transfer-rates issues become very important. For the Mac to move from doing trivial applications, like conference-room layouts, up to sophisticated applications, like printed circuit board layout, greater transfer rates are imperative."

Getting higher SCSI performance isn't just a matter of plugging a new controller chip into the Macintosh motherboard, however. A SCSI chip must be inserted into both the microcomputer and the external device before higher performance can be achieved. In most instances, the handshaking structure of the SCSI protocol will allow a direct substitution. "The entire reason for SCSI protocol in the first place," said Dedrick, "is for a device manufacturer to improve performance without changing the hardware or software."

The Logic L5380 SCSI controller chip is designed to be a direct substitution for the NCR 5380, the controller Apple uses in the Macintosh. A design engineer for Dual Systems (Berkeley, CA), one of the beta test sites for the L5380 and a company that currently manufactures an NCR 5380-based SCSI interface controller card, told Microbytes that the maximum throughput measured using the NCR chip was 0.63 megabytes per second. After substituting the L5380 chip (and modifying a delay line), measured throughput on the same card was 1.12 megabytes per second. The spokesperson went on to say that Dual Systems would more than likely be switching to the Logic Devices controller chip in the near future.

The 68-pin Adaptec AIC-6250, on the other hand, operates at asynchronous data-transfer rates of 3 megabytes per second. The manufacturer claims, however, that a transfer rate of 5 megabytes per second is possible with synchronous communication. Adaptec further claims that, when operating in a computer across a 16-bit memory bus, the AIC-6250 can transfer data at up to 20 megabytes per second. According to the company, the AIC-6250 provides all the functions necessary to implement a standard SCSI interface in a host computer.

Adaptec also recently introduced what it claims is the personal computer industry's first intelligent multitasking AT-to-SCSI host adapter, the AHA-1540. The company claims the AHA-1540 will enable clone makers to challenge the speeds of IBM's Micro Channel architecture. Adaptec says the adapter is ideal for 80286- and 80386-based multitasking, multiuser machines running under Unix or Xenix. Across the AT bus, the AHA-1540 will support synchronous transfer rates of 5 megabytes per second (asynchronous rates of 2 megabytes per second) with burst rates of up to 10 megabytes per second. Standard AT hard disk controllers transfer data at 160K bytes per second.

The AHA-1540 is intelligent in that it automatically distinguishes between synchronous and asynchronous peripherals and adjusts itself accordingly. Up to 255 simultaneous tasks can be performed through a programmable "mailbox" system (threads) through which the host communicates with the I/O subsystem.

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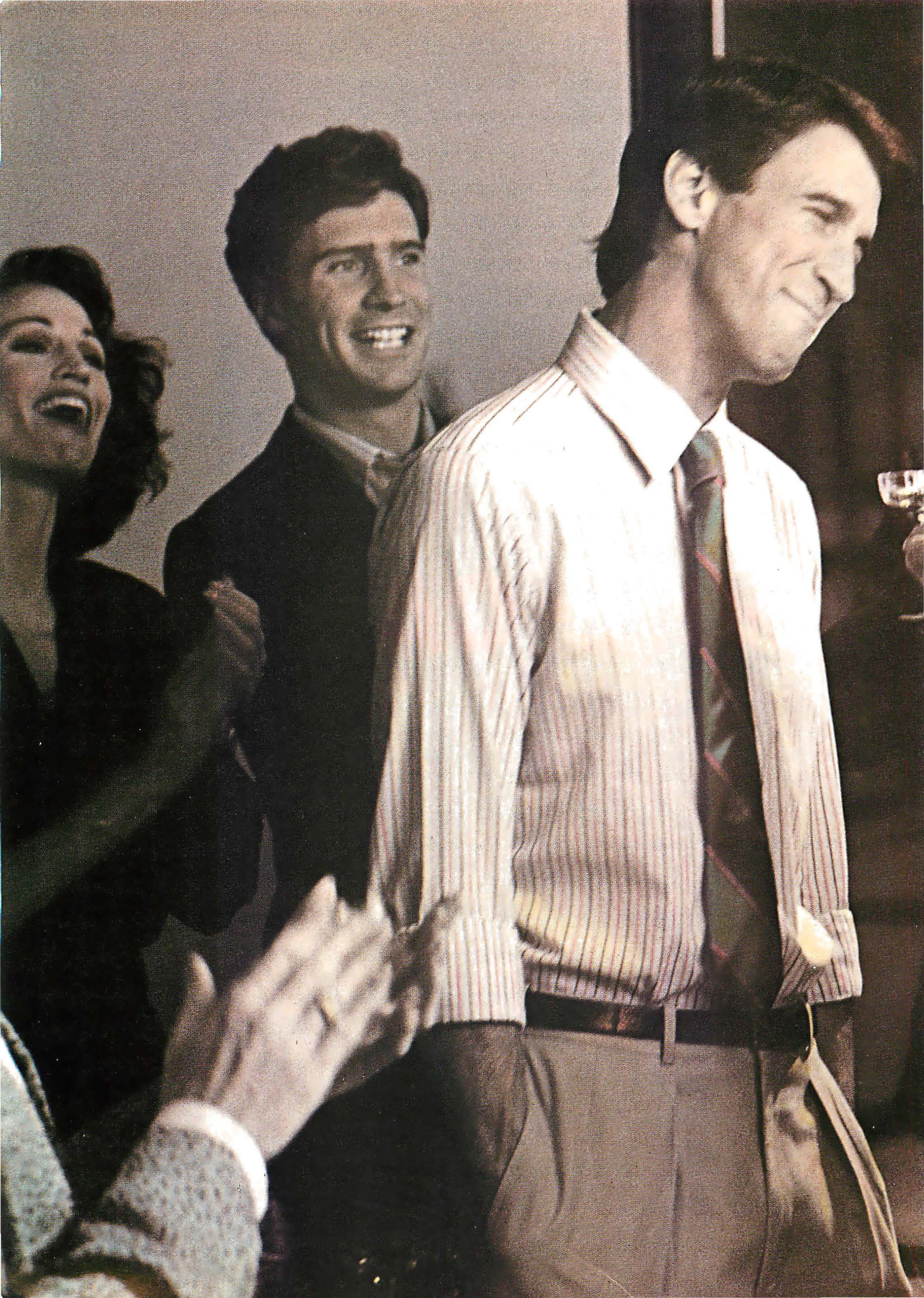
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LETTERS

and Review Feedback

Ada Compiler Update

I would like to correct a couple of errors and misconceptions in "Ada Moves to Micros" by Namir Clement Shammas (July).

First, Mr. Shammas reviewed version 1.6.1 of Janus/Ada. Version 1.6.2 has been available since the end of January. The major new features in version 1.6.2 are enumeration I/O and aggregates. It also supports code trimming (which removes unused subprograms from your result code). The compiler speed was increased, the code generator was improved, and various bugs were removed.

The implementation of exceptions was complete in both 1.6.1 and 1.6.2. Additionally, in table 1 under the "Generics" heading, the "No"s should be "Yes"s, and the "Yes"s should be "No"s. The use of the /Z (optimize) option on the compiler and the /T (trim) option on the linker make a big difference in the code size and a small difference in the running time. Both these options are available in version 1.6.2, and /Z was available in version 1.6.1.

In his conclusion, Mr. Shammas states that Janus/Ada is useful for novice programmers, but that it costs too much. We offer two other packages, and both contain essentially the same compiler as the reviewed D-Pak. Novices can purchase our introductory C-Pak, which costs $99.95, or they may prefer the additional capabilities of our ED-Pak, at $395.

We are in the process of submitting the compiler for validation. The validated version of Janus/Ada should not be significantly slower compiling in any of the tests found in the review than version 1.6.2, because all the time-consuming features are already implemented. The features not implemented can affect the compiler speed only if they are used.

Randall L. Brukardt
Director, Technical Operations
R.R. Software Inc.
Madison, WI

Statistical Errors

On the whole, the comparative review "Statistics on the Macintosh" by Richard S. Lehman (July) was informative, balanced, and objective. However, the first four tables that accompanied the article contained many factual mistakes about our product, Systat version 3.0.

First, the price is correctly stated in the text as $595 but incorrectly in table 1. Second, Systat has a capacity of 200 variables, not 100, except in the data editor. Finally, the tables incorrectly stated that Systat does not provide Z-score transformations; the descriptive statistics minimum, maximum, and standard error; paired t-tests; beta coefficients in regression; correlation I/O; the Durbin-Watson statistic; the Mann-Whitney U test; or the Wald-Wolfowitz runs test.

Systat is now shipping a new release, Systat version 3.1 for the Macintosh, which provides a more complete Macintosh interface, a wide range of high-resolution statistical graphics, and optional support for 68020 and 68881 machines.

David Koepke
Director of Statistical Research and Development
Systat Inc.
Evanston, IL

Sort Subjects

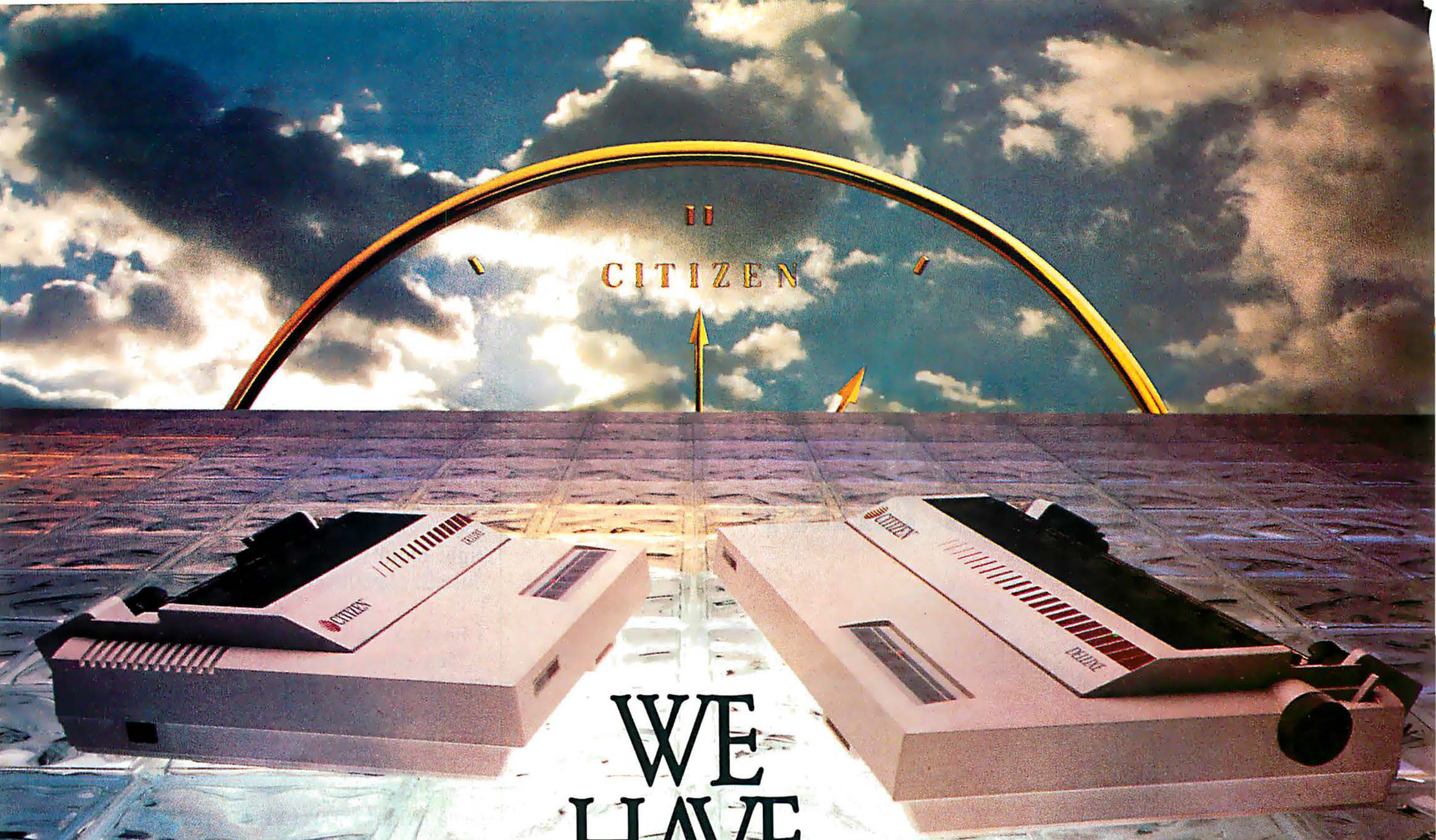
After having read "Sorting Out the Sorts" (July) and "Search and Destroy" (August) by Dick Pountain, I would like to make several comments. To begin, I'd like to try to shed some light on the question of why DOS Sort runs slower than Usort.

Let me assume DOS Sort is a quadratic time algorithm, as asserted in "Sorting Out the Sorts." Judging from the PC-DOS version 2.0 documentation, the largest file that can be used with this utility is 64K bytes. I think it is a reasonable guess to say that DOS Sort is probably an internal sort. At this point, it is safe to say that the crux in comparing Usort and DOS Sort lies in the number of comparisons made. One must be reminded by an implication that was made that the comparison as to why DOS Sort does not perform as well as Usort may be improper. Specifically, neither DOS Sort nor Usort tackles the same problem, properly speaking. In any event, I'd expect that the DOS Sort utility is in fact an array sort (as opposed to Usort, which uses dynamically allocated lists). DOS Sort will make about $0(c(n**2))$, where c is about 1/4 to 1/2, comparisons on the average and about $0(k(n**2))$, where k is about 3/4 to 3/2, array element moves. For those interested, the constants are used in a more general way than they should be, but the values do serve to provide some idea of the approximate overhead involved with DOS Sort.

But what about Usort? Certainly it is a quadratic algorithm like DOS Sort. However, since Usort uses a hash table with 26 linked lists (one for each letter of the alphabet), the average, expected number of compares for an element at any one time will be $n/26$. That is to say, unlike DOS Sort—which must go through its entire list of elements to correctly place an element—Usort, by virtue of its hash function, "knows" where to begin its search. It is clear that inserting an item into the proposed hash table will take constant time (once the correct position has been located). You can make a rough estimate that Usort will make about $0((n**2)/26)$ compares on the average and about a linear number of element moves (to account for the insertion of all the items into the hash table). Of course, there is always the consideration of word frequency and the like, but I think the illustration of the overhead involved indicates why Usort may run faster than DOS Sort.

My final comments to these articles are directed to the choice of data structures for this problem. It seems to me that splay trees (Robert Tarjan's term for self-adjusting binary search trees) would be a more appropriate data structure for the book-indexing problem. As pointed out, certain words are used more frequently than others. With splay trees, you can obtain logarithmic amortized time bounds on the search and insertions. Further, splay trees will adapt to changes in the request patterns for various items in the tree. This property makes it especially useful in dealing with the boring part of

continued



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the problem. Nevertheless, splay trees can be used to speed up the hash table proposed. Essentially, the main data structure as proposed can be kept. The list-node record definition must be changed to have left and right list-node pointers rather than just the next pointer.

Inserting something into the correct hash-table location is a matter of splay-searching the tree at the correct location. Once the splay-search process is completed, depending on whether the item to be inserted is less than or greater than the root node, make the root node its left or right child. You can modify the procedure SquirtOut in the following way:

```
{ Recursive InOrder Binary Tree
  Traversal version of SquirtOut }
PROCEDURE SquirtOut (list:nodeptr;
  VAR outfile:text);
BEGIN
  IF list<>NIL THEN
    BEGIN
      SquirtOut(list^.left,
        outfile);
      Writeln(outfile,
        list^.info);
      SquirtOut (list^.right,
        outfile);
    END;
END;
```

As a result of using the binary search tree structure, you can obtain the following properties useful for the book-indexing problem:

1. Searches and insertions are done in logarithmic time.
2. Binary searches are inherent in the data structure. (This particular fact is extremely appropriate to the problem posed in "Search and Destroy.")
3. SquirtOut runs in linear time.
4. The search and insertion procedures for splay trees are conceptually easy to develop and easy to maintain (unlike their classical counterparts).

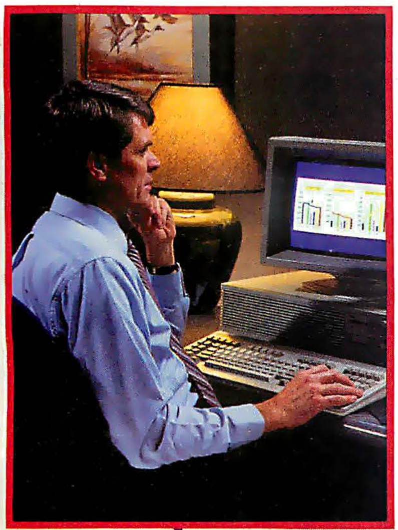
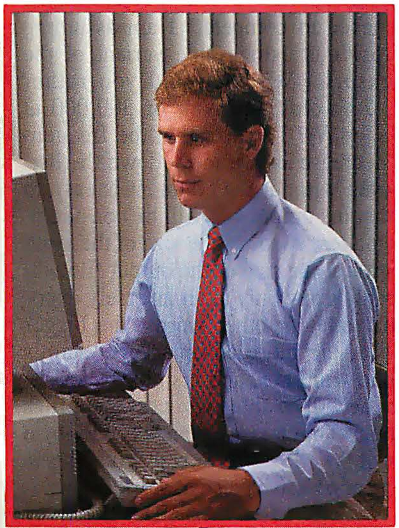
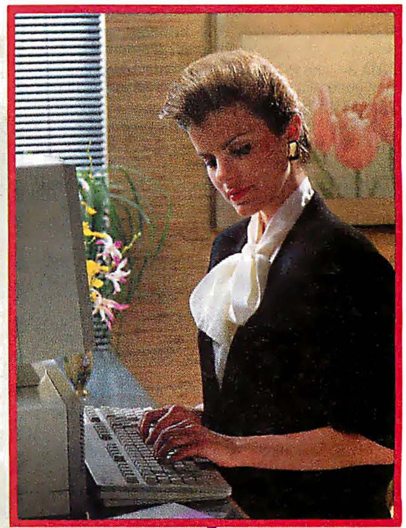
Andrew M. Liao
Leonia, NJ

I loved the article "Sorting Out the Sorts" by Dick Pountain. However, he made a mistake in assuming that Usort would be more I/O-bound. First, every system has an I/O buffer for the disks, which I would estimate in MS-DOS is perhaps 1K byte. (I wouldn't know for sure, since I own an Amiga, which allows you to change the buffer size for each disk drive.)

Anyway, the read file time should be about the same for both. But since his ingenious method weeds out all duplicates, the write time will be significantly re-

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Print Master lets people share printers

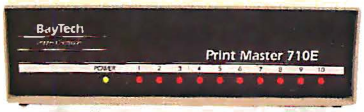




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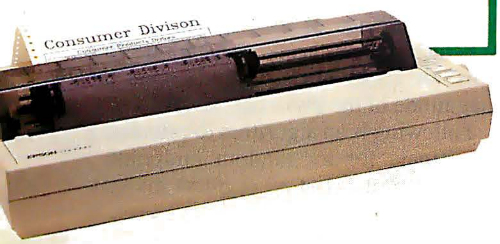
An advantage of Print Master is its flexibility: Any port can be a computer port or a printer port. Choose from eleven models with different combinations of serial and parallel ports. Print Master internally converts serial to parallel and vice versa on combination serial/parallel models. Six ports, $795. Eight ports, $895. Ten ports, $995.

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duced. Using the Brown University Corpus, which contains 1,012,801 words, the top 20 words alone account for over 30 percent of the total. His sort is still a $0(N^2)$, but it's on such a smaller number of words that the $0(N \times \log_2 N)$ has almost no chance to compete. (I am assuming Microsoft is using some variant of the Quicksort.) Which would you rather sort, 20 words at $0(N^2)$, or 300,000 at $0(N \times \log_2 N)$? I realize that the frequencies decrease as you move down the list, but even without the count, it is easy to see that his output file will be considerably smaller. Also, as the size of the input file grows, the size of the output file will probably grow only at an inversely exponential rate. In other words, the bigger the file, the more advantage Pountain's method will have, and his times show it. Also, he will be able to process input files of much larger sizes than the 63K-byte limit of the MS-DOS Sort utility. This is a very impressive piece of work!

David Harvey
Salt Lake City, UT

In "Sorting Out the Sorts," Dick Pountain asks how his Usort program can be an order of magnitude faster than the MS-DOS Sort utility. There are two possible answers.

First, programs written for specific applications are always faster than general solutions. For instance, a Turbo Pascal program is going to average a set of numbers faster than a Lotus 1-2-3 spreadsheet. Removing duplicate words while sorting the file has a definite impact on this specific program. Assume Mr. Pountain's 15K-byte file has 2000 words in it and that each word is duplicated (on average) five times. If Sort is as fast as theoretically possible ($0(n \log n)$), then it would complete in 0(2000 log 2000), or 0(22,000). (Read $0(x)$ as "big 0 of x." The symbol ** is the exponentiation operator. All my logs are base 2.) Without eliminating duplicates, Usort would take 0((2000)**2)), or 0(4,000,000). But by eliminating duplicates, Usort takes 0((2000/5)**2), or 0(160,000), a 25-fold increase in speed.

Second, one way that parallel computing systems increase their computing power is by dividing a given problem into subproblems and assigning each subproblem to a separate CPU. (Quicksort is based on dividing an array of items in two smaller arrays that are then recursively sorted by Quicksort again.) Mr. Pountain divides his problem into subproblems by using 26 lists arranged by the first letter of the sorted words. If the first letters of words were distributed evenly among all letters (which they are not), it would reduce the execution time of Usort to 0((400/26)**2), or 0(236). This is two orders of magnitude faster than Sort.

Keep in mind that when considering theoretical speeds of sort algorithms, they are considered only for a large number of items to sort, only the number of comparisons are counted (it is assumed that the time to compare two items far outweighs the time spent moving them around), and they are accurate only to within an arbitrary constant. Thus, you can have the effect of a well-written Bubble Sort sorting an array faster than a poorly coded Quicksort (for up to perhaps several hundred items). On examining the algorithm Mr. Pountain used, it is easy to see how he can achieve a factor-of-10 improvement over the MS-DOS Sort utility.

Gregory Rochford
Lewisville, TX

Landscape Simulation

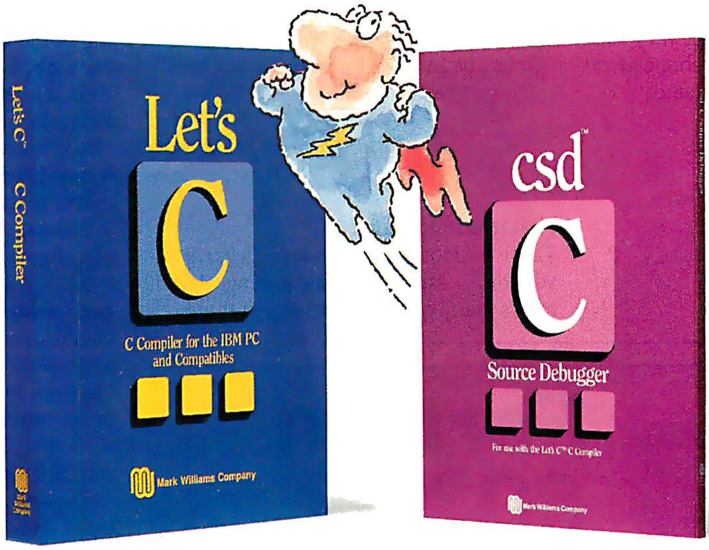
In the Programming Project "Creating Fractals" (August), William A. McWorter Jr. and Jane Morrill Tazelaar briefly refer to "imitating or modeling nature." Another approach to fractals, commonly used to simulate landscapes, includes the use of random numbers. This technique is easily applied to closed geometric shapes. Although true landscape simulation also uses more advanced graphics techniques, interesting wire-frame landscapes can be generated using theory similar to that of Heighway's dragon.

Using a square as an example, the shape is subdivided into quadrants, each of which is in turn subdivided into quadrants. This process continues in a recursive manner until the desired level of detail has been reached. Comparing this to the dragon, day zero would be the initial square. It is divided into 4 parts on day one and 16 on day two. When the divisions are performed to produce equal parts, one gets something resembling graph paper. This is where the random numbers come in. Instead of dividing a segment at its midpoint, it is divided at a point generated to lie randomly within a circle drawn about the midpoint. This random point is not usually on the line being divided, which is what makes things interesting. In order for the same distortion factor to be applied to all levels of recursion, since the segments being divided become progressively smaller, the radius of this circle should be expressed as a percentage of the segment length. Whether you get farmland, gently rolling hills, or rocky cliffs depends upon the magnitude of the distortion factor.

Following is an algorithm to calculate a coordinate for a "random midpoint." Both coordinates of all segment division

continued

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points should be calculated using such an algorithm. Function `random` returns a random number between 0.0 and 1.0. Unless you use a machine with very fast graphics, you should draw the shape after all data points have been calculated.

```
segment_length=abs(point_
  2 - point_1);
increment = random( ) * (circle_
  radius * segment_length);
mid_point = (point_1 + point_2) /
  2.0;
sign = random( ) + 0.5;
if (sign = 0)
  mid_point = mid_point -
    increment;
else
  mid_point = mid_point +
    increment;
```

Cynthia H. Verdow
Paris, France

Fascinating, But...

Tibor A. Hoffmann's letter ("Matrix Inversion," August) is fascinating, but it raises many questions. I suggest three.

First, Mr. Hoffmann requires that the vectors representing equations have "last elements" equal to −1, a particular scaling of the equations that is unattainable if the right-hand-side vector has any zeros. This is a severe restriction (it excludes the finite-element version of Laplace's equation), and it seems unnecessary to the method. Has something gotten scrambled in the account?

Second, the two extreme cases of well-conditioned and exactly degenerate systems are indeed handled cleanly using exact arithmetic, but the way to handle ill-conditioned systems with finite-precision arithmetic is not obvious. Perhaps if one chooses to orthogonalize in the correct order, then numerical stability will be achieved. That sounds like a latter-day search for pivots.

Finally, the prospect of directly solving a large, sparse system, which is suggested by various comments in the letter, is practical only if the subspace representation stays sparse. Is there any reason to expect that it will?

At the very least, a lot of nonobvious detail has been omitted. Before I tackle that detail, I would like to see a more complete account, a working program, or preferably both. Can anyone supply either? How do I contact Tibor Hoffmann?

Philip Ekstrom
Shaw Island, WA

You can contact Dr. Tibor Hoffmann at H-1132, Budapest, Kádár Str. 13, Budapest, Hungary—Ed.

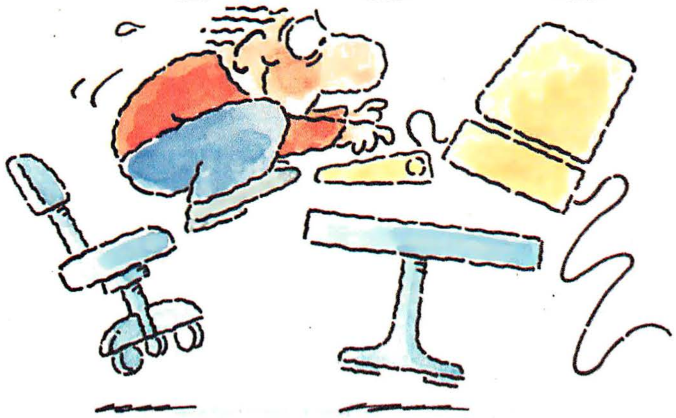
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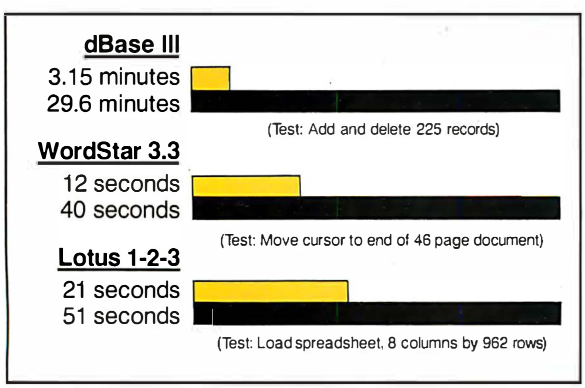
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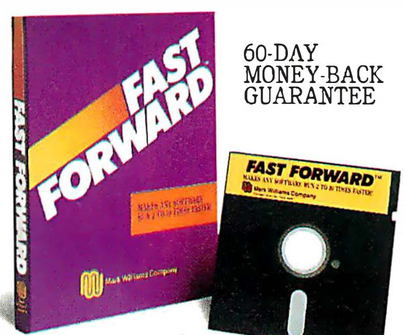
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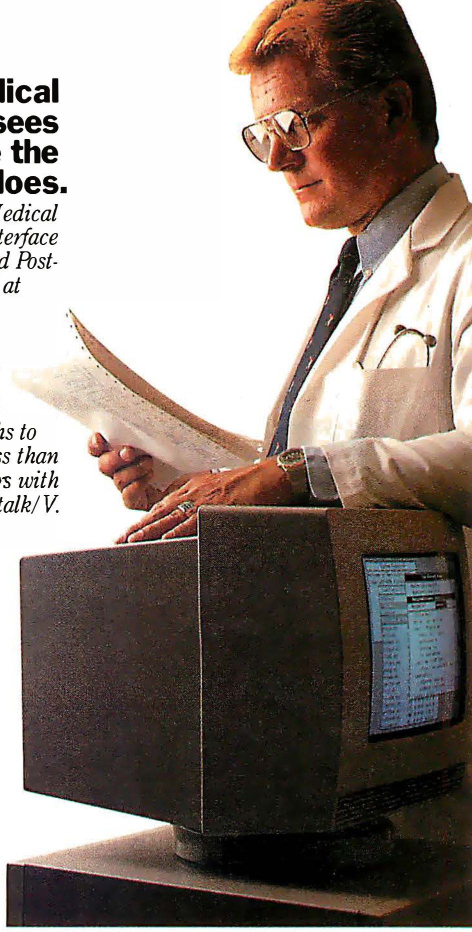
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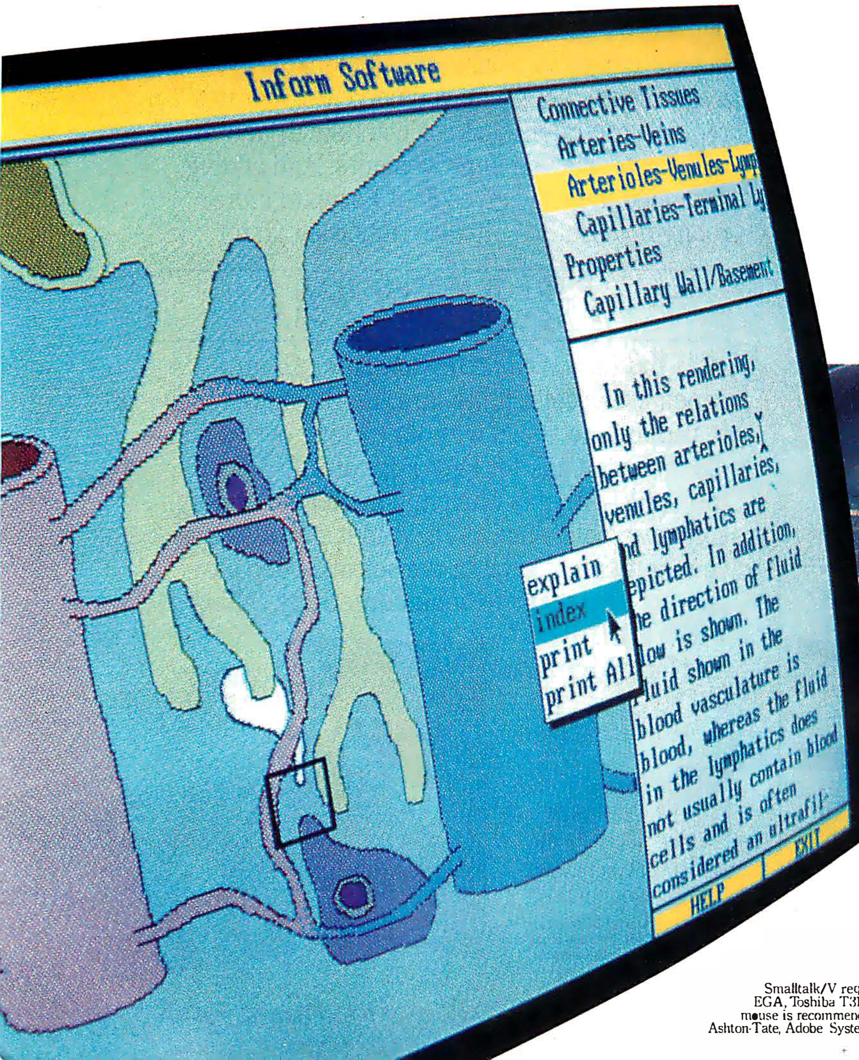


At the UCLA Medical Center, it sees patients before the doctor does.

Mike McCoy, M.D., at the UCLA Medical Center, found that he could easily interface Smalltalk/V with dBASEIII and PostScript. His application, now in use at the Clinic, turns a functional status questionnaire on each new patient into a laser printed, advisary analysis for the doctor to review prior to seeing the patient. A program like this would normally take a specialist months to produce. It took Dr. McCoy less than 100 hours with Smalltalk/V.

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It's working on Florida's freeways.

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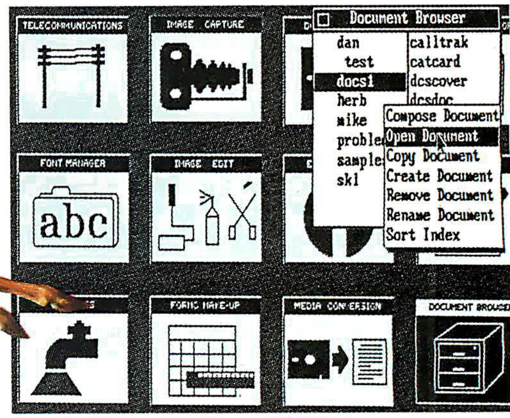


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Dr. Lee Graham, a National Park Service ecologist chose Smalltalk/V to write an application to help manage the white-tail deer population on the Barrier Islands of Georgia. Dr. Graham found that Smalltalk/V, with its visual interface and class structure, is a perfect tool to graphically simulate the complex, ecological interactions of natural systems.

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resented as 453[4], and 1.2 nanograms Digoxin as 12^{-10}.

In addition to simply reducing the amount of storage required, this method also allows for faster comparison of values, because values you might compare all have the same exponent, and only the integers need be compared. Statistics on the data are faster to compute, since integer arithmetic is faster than real arithmetic. However, this is likely to be a significant consideration only when being performed thousands of times (as on a big hospital system).

Recently, I was daydreaming about the future of microprocessors, and I wondered about the possibility of introducing shifted integers in silicon. (Granted, strings were first implemented by compilers and only years later in silicon—the advantages being speed and some standardization—the practical reader can substitute compiler for microprocessor, and I'll dream.) In my particular application, I find them useful, but as a built-in data type, they would be easier and even faster to use. To be written in silicon, there would have to be many uses in addition to my single application, but I suspect that there are.

For example, business financial calculations (to the penny) with millions or billions of dollars might be faster than BCD (again, the exponent is always −2) and more accurate after multiple calculations than reals; this is because mantissa arithmetic would be integer arithmetic. Census data might require less storage space. In the calculation of the largest prime numbers, linked lists of shifted integers (particularly in a parallel processing system) could be used.

If the idea is to be preserved in silicon, it must be described in a manner that will benefit a wide range of applications. As such, I envision three types of shifted integers: 3-byte, 6-byte, and 10-byte, loosely paralleling short integers, long integers, and 80-bit reals. The 3- and 6-byte versions would have 8 bits of exponent, and the 10-byte values would have 64-bit integers with 16-bit exponents.

(Extra decimal places can be garnered if the 3-byte value uses only 6 bits of exponent, the 6-byte value uses 7 bits, and the 10-byte value uses 12 or 15 bits, but this might complicate internal conversion to and from integers and reals. Determining the best set of sizes might be best tackled by trial and error in compilers first and later silicon implementations based on de facto standards.)

These three type sizes combined with the stringing process would enable diverse applications.

But how do you manipulate (i.e., add, subtract, multiply, divide, modulate, etc.) these new data constructs? Within the processor, all sizes of shifted integers should be compatible, and the result of manipulation yields the largest size of data type used. There should be a special carryover register for addition and multiplication that would contain the address for the amount of any carryover of the mantissa (it would then be up to the programmer how to dispose of the loss in precision, or to string this value to the result). The issue of division and modulation is a little more difficult. Should the division affect only the mantissa? This seems most appropriate when the exponent is less than zero, but what about when it's greater than zero?

There should also be a remainder register that holds the address of the remainder of division (and thus defines the modula). In this way, no data is lost, and you can even perform further division on the remainder.

Conversion would be allowed to and from integers and reals. Trigonometric,

continued

transcendental, and similar noninteger functions would be performed only after conversion to reals.

I believe this new digital data type has the potential to increase computation speed and decrease storage space (both in memory and on disk) for certain applications. It maintains the precision of integers but allows the broad range of reals, and thus it might be a useful addition to future compilers and microprocessors. Until that time, I hope someone else will benefit from using shifted integers as a defined data type. I recently read that the Intel 80486 still has 250,000 noncommitted transistors . . .

Larry Ozeran
Los Angeles, CA

Paying the πper

In answer to my letter to BYTE ("Easy As π," May) Klaus D. Mielenz's letter ("BASIC Archimedes," August) asserts, without supplying a reference, that the original discoverer of the formulas given to calculate π was none other than the great early Greek mathematician, Archimedes (287–212 B.C.).

Perhaps with generous "interpretation," this contention can be supported, but what if the formulas were presented in the following simple and recognizably useful form?

(In the following, "SQR()" indicates square root.)

1. Let $S_0 = 0$ and let $P_0 = 2$.
2. Let $S_k = \text{SQR}(2 + S_{k-1})$ and $P_k = 2 \times P_{k-1}/S_k$ for $k = 1$ to N.
3. Then the limit of P_N as N approaches infinity is π. And still more striking,
4. If for any values of P_N and S_N, $R_N = 2 \times P_N \times (1 + 1/S_N)/3$, then R_N converges to π with twice the figures of accuracy of P_N. ($N = 14$ will result in about 16 digits of accuracy for R_N.)

Practical as these formulas are for computers, they are tedious and nearly useless for hand calculation, because a square-root approximation, *to the full accuracy of the final result*, is required on each iteration.

Archimedes would have had to perform such an approximation without benefit of the presently used square-root algorithm devised by Gauss more than 1500 years later. Neither was Newton's iterative method for finding roots available, which is now the standard method used on computers.

In fact, even the unending decimal fraction was probably unavailable, because this is essentially an infinite series first sanctified, if not invented, by the calculus of Newton. Imagine, for each square root, finding an approximate fraction with an integral numerator and denominator to the accuracy required for the final result.

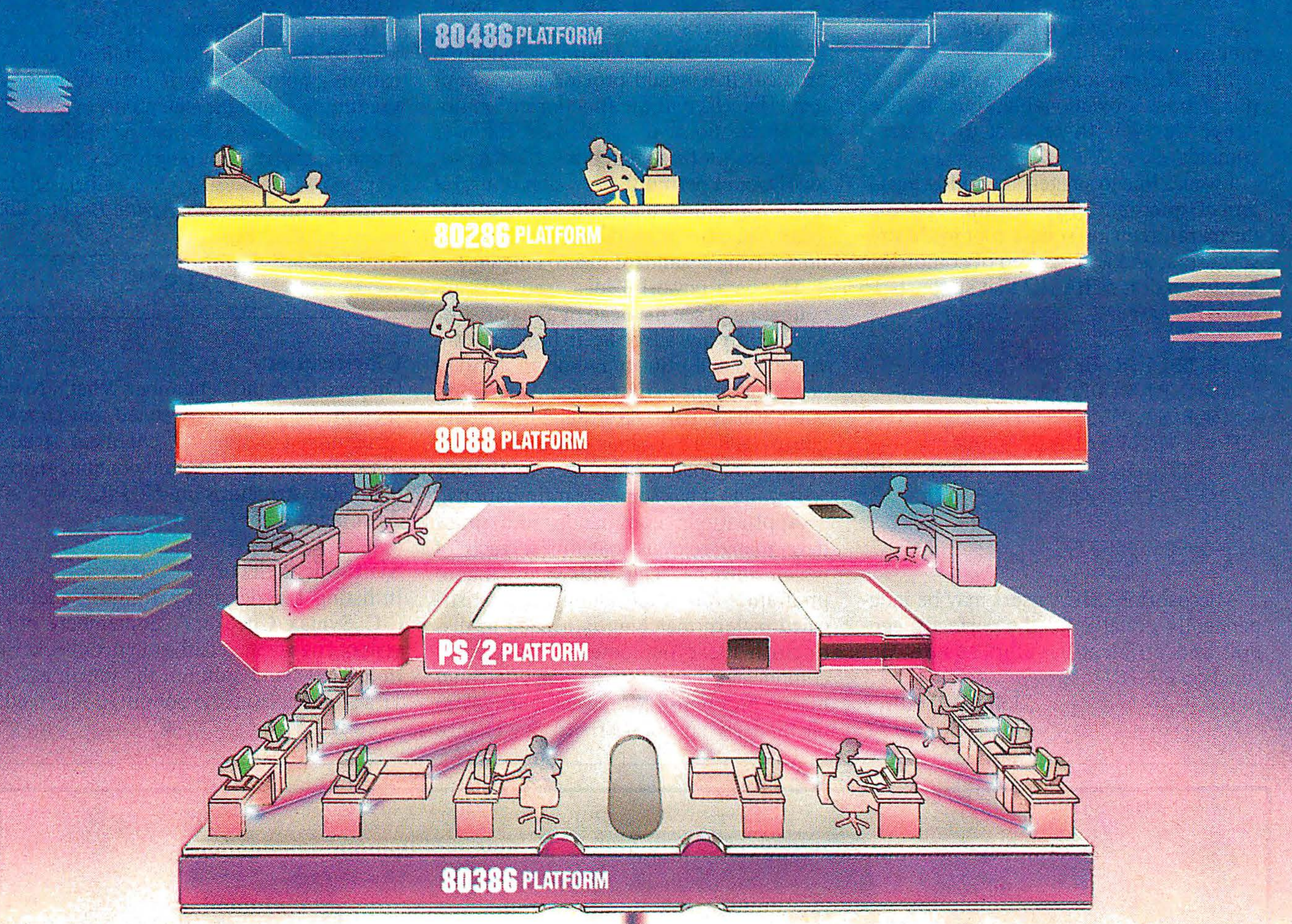
Still, there is no doubt that Archimedes was a great mathematician, and it is altogether possible that he originated these formulas in the form given. In any case, some later mathematician, with or without Archimedes's prior assistance, must have published them, and I would like to obtain such a reference and/or a relevant quote if Mr. Mielenz, or any other reader, could supply them.

As for Mr. Mielenz's alternate program, it should be noted that its completion depends on the exact equality of two successive values of $P_{(k)}$, called P# and PI#. Due to rounding errors, this may not occur in all implementations of BASIC. It is generally poor programming practice to rely on the precise equality of two computed real variables. When it does occur, extra iterations with no improvement of the final result may be required.

Correcting the typo in line 20 of the Mielenz program (replacing 20# with S#) will make the program run, but Micro-

continued

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Circle 278 on Reader Service Card (Dealers: 279)

soft BASICA users will find it still deficient, computing π to only 7 digits, not 16 digits as shown. This is because the SQR( ) function will return only a single-precision result.

Mr. Mielenz appears to find FOR ... NEXT loops objectionable, but he lives dangerously with respect to program completion.

I would like to suggest the following alternate program. My program handles the extra-precision square root for Microsoft users, and it is assured of completion in any version of BASIC that supports 16 digits.

```
10 DEFDBL P,S: DEF FNP(P,S)=
   (P+S/P)/2: DEF FNS(S)=FNP(FNP
   (SQR(S),P),S)
20 P=2: WHILE S<1.99999999#:
   S=FNS(S+2): P=2*P/S: WEND: PRINT
   2*P*(1+1/S)/3
RUN
3.141592653589793
```

Microsoft BASICA users may be independently grateful for the perfectly general and efficient 16-digit square-root function FNS(S).

John T. Godfrey
Punta Gorda, FL

Powerful Idea

Bill Gates's article, "Beyond Macro Processing," which appeared in the special Applications Software Today edition of BYTE, calls for a common application protocol that would provide a programmatic interface to the functions of multiple applications, to supplement the user interfaces for these functions. Such a protocol would permit the creation of useful macro programs that combine and integrate the functions of several applications, using a standard macro language.

This is a powerful idea, and it is encouraging to see the head of a major software company advocate it in such convincing detail. But it is not an entirely new idea (in the mainframe and minicomputer arenas, IBM's Rexx and Exec2 languages and the various Unix shell languages are macro languages in Gates's sense), and it has some clear limitations.

Applications commands sometimes have many relevant outcomes, each of which must be dealt with in the macro program. Too often, though, sophisticated pattern matching is needed to distinguish these outcomes. This greatly complicates the task of writing nontrivial macro programs. Moreover, changes to the underlying applications can change both the outcomes and their distinguishing patterns, thus invalidating existing macro programs.

It is possible to overcome these problems by designing and maintaining applications commands as if they were programming-language statements or library subroutines, but this may be asking too much of applications developers.

Chris Shaw
Manhattan Beach, CA

FIXES

Clarification

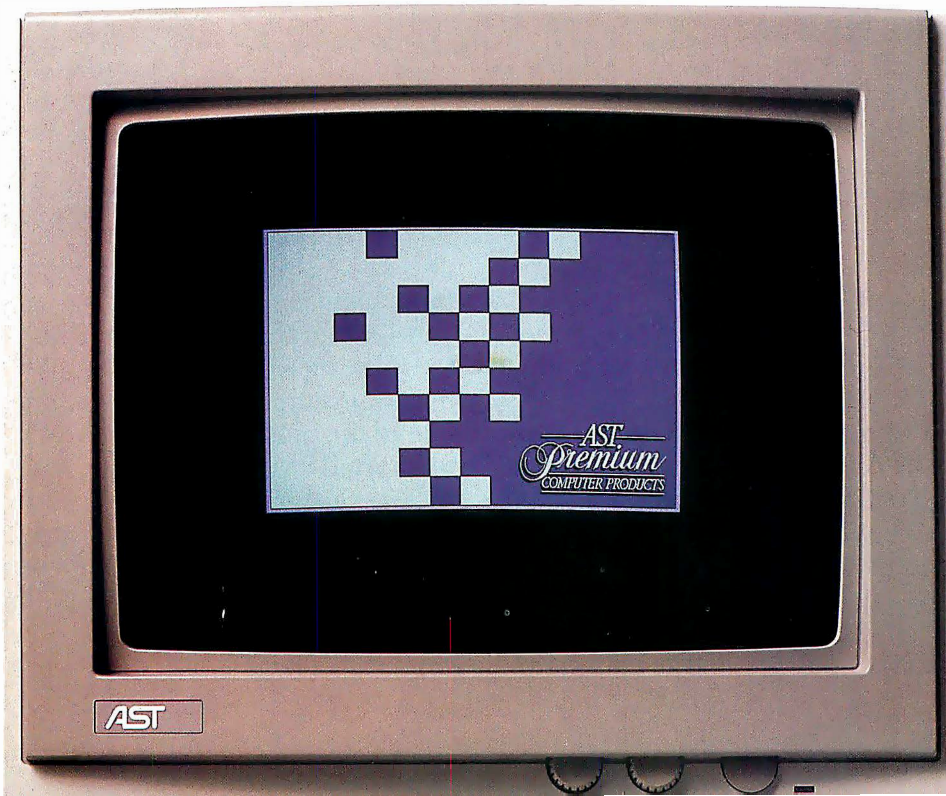
On page 62 in the September What's New section, we incorrectly stated that Draw-Structures contains 67 chemical structures. In fact, the program contains more than 300 structures in 67 PICT-format documents.

Syntactical Error

In listing 1 under Jerzy Tomasik's letter ("C Syntax Checker," September) our syntax checker needed a syntax checker. In the left-hand column, the fourth else if statement from the bottom should read else if(c == '\''). ■

Circle 124 on Reader Service Card (Dealers: 125)

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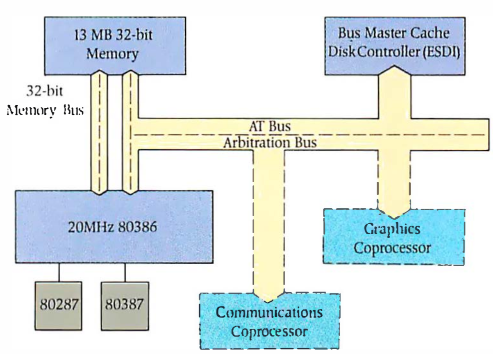


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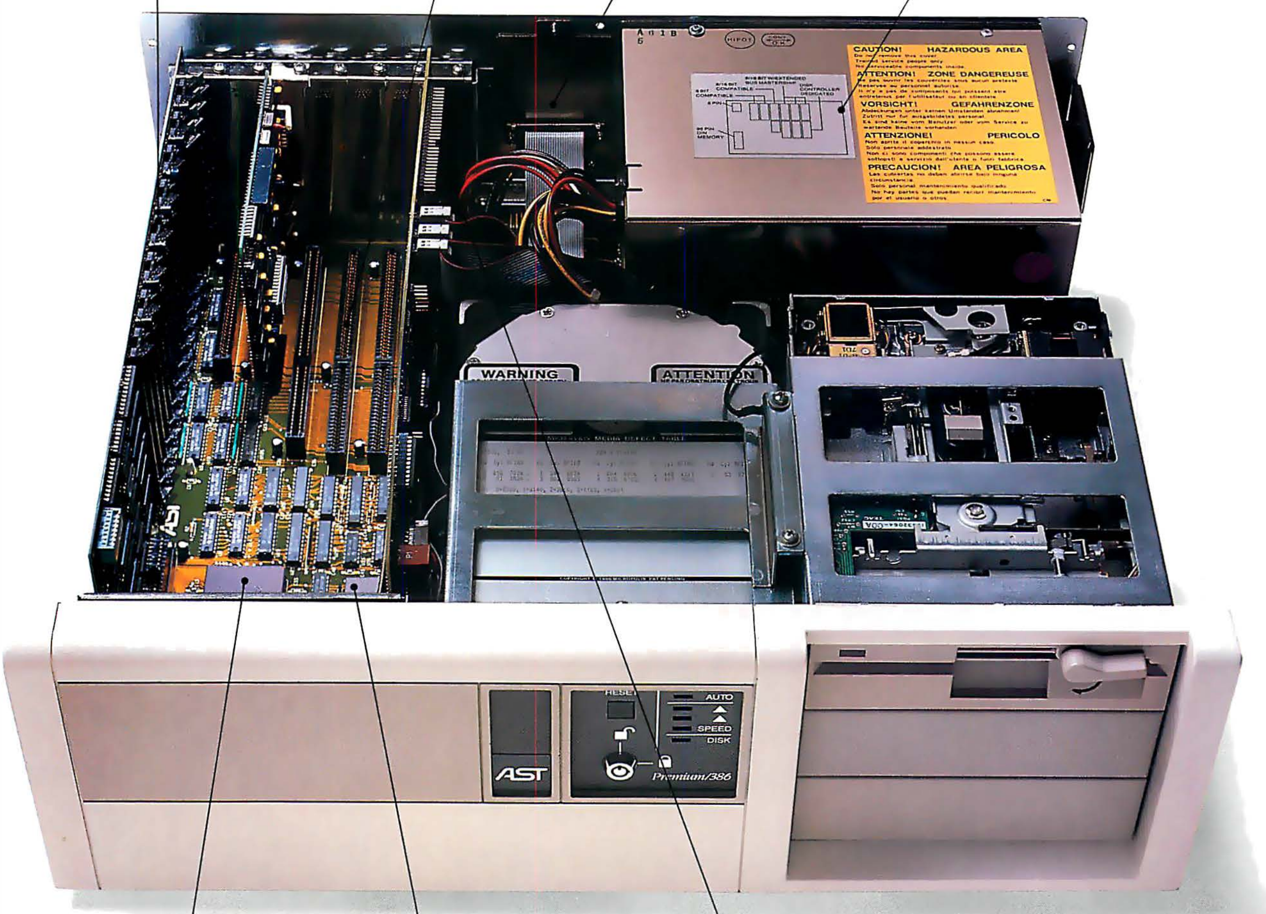
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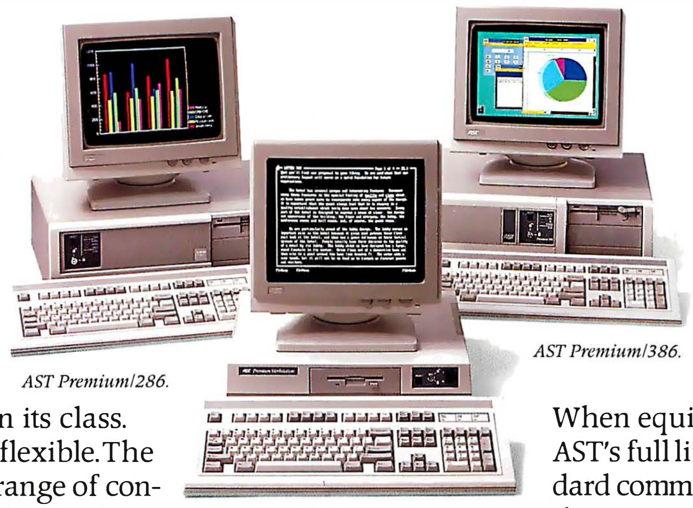
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CHAOS MANOR MAIL

Conducted by Jerry Pournelle

Editing DNA Data

Dear Jerry,

I have enclosed a clipping from the PC-SIG newsletter about the International Association for Scientific Computing in Sunnyvale, California, and its CD-ROM for biotechnology databases. While I am investigating it further for my own purposes, it seems like the concept might be something you would also be interested in discussing.

The explosion in DNA sequence information, and the multitude of ways that the biological scientist needs to look at it, is creating real problems in terms of efficient programs for analysis and data formatting. I'm hoping that this may be a partial solution. As an example of the problems, I've enclosed a page of aligned sequences from the mitochondrial DNA of a number of animals in the artiodactyl species. [Editor's note: *This species includes hoofed mammals with an even number of functional toes on each hoof.*] Each sequence was compared to a cow, using the program NUCALN (Wilbur and Lipman, *Proceedings of the National Academy of Sciences*, volume 80, pages 727–730). So far, so good.

Unfortunately, each line then had to be entered (more or less by hand) using an editor for the final compilation. Worse, when any length changes were made, every line past the change (in the whole 13-page list) had to be adjusted to maximize the alignment when all six species were simultaneously compared.

There are lots of editors out there, but none will let you word-wrap down 12 lines rather than to the next line. I'm pretty sure there is no general market for that particular function in an editor, but any molecular biologist comparing more than one DNA sequence would love it; without some way of efficiently sharing information and programs, we either all write something ourselves, or just spend all that time editing by hand.

Finally, I think the "computer book of the month" listing is too valuable to see only once, particularly for us less literate computer users. How about summarizing your opinions for the current "best" Turbo Pascal tutorial, or whatever, in every third or fourth issue, and updating it as new books appear?

Philip J. Laipis
Gainesville, FL

Thanks for the information. Alas, my column is usually too long every month to begin with; there's no way I can add more, so to put in new features I'd have to cut some out. Sigh.—Jerry

Revelation

Dear Jerry,

I'm writing primarily to thank you for all the good advice you've given in your column, and secondarily to offer a suggestion.

It strikes me as odd that I have never seen Revelation mentioned in your column, because I think it is exactly the kind of program that you would really enjoy. Not, I expect, that you do much database work, but if you do anything at all beyond a mailing list, it's unbeatable. I do some database work for other people as a sideline, as well as a considerable amount of teaching of microcomputer applications, so I watch people coping with their information-retrieval problems all the time. About 90 percent of them are trying dBASE III Plus these days, and while they are losing less hair than they did with dBASE II, it's still an essentially wrong-headed program. There are so many problems that it can't handle without extraordinary contortions.

Over the two years that I've been working on this stuff, I've come to the conclusion that if it's simple enough for dBASE to handle, you should use WordPerfect, which does a reasonable job with lists of various types. If it isn't that simple, then you need something with actual power, like Revelation, or, for multiuser applications, Pick. The problem with Revelation is that it isn't cheap, but neither is dBASE, and Revelation will get the work done. It's radically different from all microcomputer databases except Pick and Cornerstone, and there is literally no data problem that you can't handle with it.

In case no one has ever sent you a copy, Revelation is made by a group in Seattle called Cosmos.

David Keeble
Almonte, Ontario, Canada

Actually, when I need a database, as we increasingly do here, I find Q&A about the simplest to set up and use, at least on a big and fast machine.—Jerry

continued

Swiss Computing

Dear Jerry,

As the only executive for my company living permanently east of the Atlantic Ocean and west of the Pacific (in Switzerland), I have an IBM PC setup that allows me to do all my work wherever I am and to get it back to the right point. With the 6- to 9-hour time difference between my region and the main office, portable telecommunicating is vital. Let me bore you with my solution to the problems you described in your March 1987 article.

In my office I have two Chinese clones from Multitech—one with dual floppies, and one with a 20-megabyte hard disk drive. I also have a Finnish modem from Nokia that came with the necessary subscription to the Swiss PTT packet-switching service (Telepac). At home I have an old Columbia VP. The "glue" that holds this all together is my Toshiba T1100 Plus with its built-in 1200-bit-per-second modem.

My company uses the GTE Telemail electronic mail system, and I have two mailboxes—one in my name, and one for the office. This is for the convenience of my secretary and myself. I use WordStar for my text preparation. I do an awful lot of writing, but sticking with WordStar has proven to be less nerve-wracking than learning something better. I have cobbed together an external 5¼-inch drive for the Toshiba that allows the transfer of data between the Toshiba 3½-inch media and the 5¼-inch clone stuff.

When I travel—practically all the time—I take the T1100 Plus and a shirt pocket full of those nice little robust 3½-inch disks. One of them is labeled "Travel Master Disk." It has WordStar, Smartcom II, SideKick, WSIIASCII, and ASCII2WS, and a couple of DOS utilities. Sometimes I throw in Lotus 1-2-3 and my ciphering program from Lightning. In the side pocket is a telephone cable and a standard American telephone plug with a couple of pigtail wires and two very small alligator clips. Of course, I always carry a small screwdriver.

Almost every hotel room has a direct-dial telephone these days. It is a short job to take the cover off either the plug or the phone itself and to parallel the American plug to the line, thus giving you a connection "just like home." From there on, it is easy to dial the Swiss Telepac, activate my macro for Telemail sign-on, and send out all my stuff. In the U.S., it is even easier (and cheaper).

Also, almost every office I visit has a Centronics-compatible printer that lets me hand over new or revised documents on the spot. If I do something on the spreadsheet, I first print it to a disk and then to the paper, avoiding the nuisance of carrying along (and adapting) the driver utilities. Your recent problem of not being able to get an ASCII file by printing a WordStar file to a disk first is no doubt attributable to finger trouble. The procedure works.

In summary, over here we contend with different power-line connections in each country, a dearth of telephone connectors (and those that do exist are all different), no real toll-free service, exorbitant packet-switching costs, and people who think that you have committed a capital offense by taking the cover off a telephone. Notwithstanding these obstacles, I travel and telecommunicate with the greatest of ease.

James A. McInnis
Trogen, Switzerland

Between my alligator clips and a bit of ingenuity, I've managed to communicate from most places, although I guess I'd hate to have your problems.

The Travel Master Disk is indeed important. —Jerry ■

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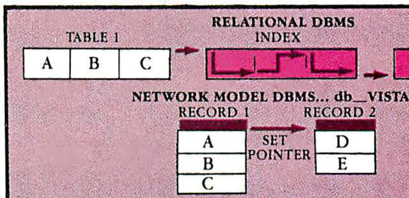
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BY117

ASK BYTE

Conducted by Steve Ciarcia

Various Sources

Dear Steve,

Please send me information and addresses of companies that sell the following software (with source code): MS-DOS text editors; pop-up program libraries and RAM-resident program management; EGA and Hercules drivers and libraries; graphics algorithms' implementations (C or assembly language); copy-protection techniques; memory caches; hard disk management; and DOS shells.

I wonder if you could also point me in the direction of sources of information in the following areas:

- Magazine articles, books, and newsletters about the undocumented and more sophisticated aspects of MS-DOS
- Information regarding special boards for floppy disk and hard disk applications
- Manufacturers of products for photocomposition on the IBM PC

Thanks for whatever help you can provide.

Armando Camargo Filho
Sao Paulo, Brazil

I don't have any sources for all the items you list, and since source code is what you really want, your choices are going to be somewhat limited.

A good source of pop-up utilities, hard disk management, memory caches, and various RAM-resident programs (all under MS-DOS) is public domain software.

Source code is available from the special-interest group areas on CompuServe (if you don't mind spending the time and money it's going to take making an international phone call). You can also obtain most of this software by writing to the following groups: Public Domain Software Center (533 Avohill Dr., Vista, CA 92803), New York Amateur Computer Club (P.O. Box 106, Church St. Station, New York, NY 10008), and PCS Software Service (1040 East Chapman Ave., Orange, CA 92666, (714) 771-3560). You can write for catalogs and additional information.

C Source Inc. (12801 Frost Rd., Kansas City, MO 64138, (816) 353-8808) and Entelekon (2118 Kimberly, Houston, TX 77024, (713) 468-4412) sell graphics libraries with source code and support for CGA, Hercules, and EGA display systems. I haven't used either of these libraries, but they seem to contain all the standard graphics primitives.

The book Programming Principles in Computer Graphics *by L. Ammeraal (John Wiley & Sons Inc., One Wiley Dr., Somerset, NJ 08873) also has a good selection of graphics algorithms, along with C implementations in device-independent form.*

Editors, compilers, text formatters, and other programs are advertised by the C Users Group, which you can contact at P.O. Box 97, MacPherson, KS 67460, (316) 241-1065. An editor with source code is available from Magma Systems, 138-23 Hoover Ave., Jamaica, NY 11435, (718) 793-5670.

For information about the documented and undocumented features of MS-DOS, there are several magazines in addition to BYTE. *A couple of the better ones are* Dr. Dobb's Journal of Software Tools *and* Micro/Systems Journal. *The address for subscriptions for both these magazines is P.O. Box 3713, Escondido, CA 02025-9843.*

For programming information about MS-DOS, it is hard to beat the IBM DOS Technical Reference Manual, *available from IBM dealers. The Peter Norton books are also good. The most recent one,* The Peter Norton Programmer's Guide to the IBM PC, *contains the best summary of MS-DOS functions. It is available from Microsoft Press, 13221 Southeast 26th, Suite L, Bellevue, WA 98005.*

On your question about hard disks: In general, hard disk drives for the IBM PC family use an ST-506 type of format, and recently run-length-limited controllers have become popular. A number of SCSI controllers are also appearing on the market. These will usually be under the control of DOS, but you can address individual sectors by writing programs that use BIOS calls. See the advertisements in BYTE *for a wide selection of drives and controllers.*

The closest things to software for photocomposition on an IBM PC are programs like TEX from Addison-Wesley Publishing Co. or Personal TEX Inc., Manuscript from Lotus Development Corp., PageMaker from Aldus Corp., and Ventura from Xerox Corp.—Steve

The Big Red Switch

Dear Steve,

I am interested in adding a reset switch to my AT (80286) clone. I would appreciate it if you could show me a schematic of a reset switch. Such a switch would prove invaluable to me, especially when I'm writing assembly language programs that cause the computer to freeze up. I understand that grounding the microprocessor's reset pin does not result in a complete reset.

Any light you can shed on this matter would be very helpful.

Rick Retter
Danbury, CT

There is no reason you can't reset the 80286 using the reset pin. Grounding doesn't do it, however, because that pin is held low during normal operation. The proper procedure is to raise the reset pin high for a minimum of four clock cycles, then return it to low.

This type of reset is a cold boot—the same as turning off the Big Red Switch.
—Steve

Life with Ozzy

Dear Steve,

I am currently sitting with the window open and an icy wind blowing in, praying that Ozzy will let me get this letter off to you. As you might guess, the trouble appears to be overheating. Ozzy is an Os-

continued

IN ASK BYTE, Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to
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Due to the high volume of inquiries, we cannot guarantee a personal reply, but Steve and the Ask BYTE staff answer as many as time permits. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

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MICROSOFT LANGUAGES NEWSLETTER VOL. 2, NO. 11

Dear Reader:

When we introduced the Microsoft® Languages Newsletter in 1985, we had just one goal in mind: improving communications with the people who use Microsoft languages.

We wanted to communicate to you the technical advances underway at Microsoft and get feedback from you about how we could make additional improvements to our products.

Everything we do at Microsoft is built around a vision: to create the software that puts a computer on every desk and in every home. We know that many of you share that vision with us and are working toward it in the development of your own programs.

We know that in order to make this vision come true, we need to supply you with effective development tools—such as the Microsoft CodeView® debugger, Microsoft QuickBASIC and QuickC™ programming languages, and Microsoft C Optimizing Compiler.

But we also know that we need your help to achieve our vision of the future. That's why, back in January, we asked you to share your visions of the ideal programming environment. Your response was tremendous. In fact, we're already exploring many of your ideas, including language enhancements to support windowing environments, a general programmer's editor, and a "super" MAKE facility.

These are just a few examples of how your ideas and suggestions have helped us shape our future product plans. From the very beginning of the Languages Newsletter, your feedback has been invaluable. And that's why we want you to be part of some important changes.

As we look to the next couple of years, we recognize that developers will want to create more global solutions; solutions that will encompass languages, operating environments, and networking. With that in mind, we have decided to transfer our resources from the Languages Newsletter to the Microsoft Systems Journal*—a bimonthly publication covering the broad scope of systems-related issues.*

Because the Microsoft Systems Journal *will include much of the information you're used to getting from the Languages Newsletter, and because we value your active participation in shaping future products, we'd like to offer you a free issue of the* Microsoft Systems Journal.

The issue you'll receive contains detailed information about Microsoft Operating System/2 and the Microsoft OS/2 presentation manager. It gives you the inside story about where we're going, including an interview with Gordon Letwin, one of the chief architects of Microsoft OS/2. There's also a special section entitled "Ask Dr. Bob," with detailed Q&A's on subjects ranging from Microsoft Windows printer drivers to using Microsoft C math library functions in an assembly program.

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borne 1 with a double-density disk addition. Now, after many years of faithful service, Ozzy is getting persnickety in his old age. He works perfectly for an hour or so, then gives me a BDOS ERROR on drive 1, and he won't reboot until after I cool him off.

I took him to the one remaining repair shop here for Osbornes, but he was nicely cooled by the trip through the Finnish winter and worked perfectly through all the diagnostics without ever overheating. The repairman suggested a new copy of WordStar and a head cleaning—which I agreed to—but Ozzy still gives up now after an extended work session. Any suggestions besides working out in the snow? (I wrote a book using Ozzy called *The Rest Principle*, about the importance for rest in brain functions. Could Ozzy be jealous?)

I have a second question concerning communication between Ozzy and my IBM PC at work. I used a Baby Blue Card with my PC, but then I got an AT, and no one seems to know if the Baby Blue Card can work in it. I can't find a supplier here anymore to ask, and there is no answer from the Baby Blue manufacturer in the U.S. Do you know if it will work? Or is there a better way to carry text between Ozzy and the AT?

David Sinclair
Helsinki, Finland

Ozzy is not jealous; he just read your book and decided to follow its advice. That's the trouble with using computers for writing—they get ideas.

More to the point, Ozzy probably has developed a temperature-sensitive chip. If the error occurs only on reading drive 1, my guess is that the chip is either on that drive or the drive controller.

How to fix it? First, if it hasn't already been done, I suggest giving Ozzy a good cleaning. Blow and/or brush out all the dust, and make sure all the vents are open so that he gets plenty of air. If the trouble persists, the next thing is to try heat or cold. Cold is preferable, because there is less chance of doing damage. Run Ozzy with the case open until he begins to act up, and then chill chips individually until the read error goes away. You will then have identified the bad chip. You can use a spray cooler like Component Cooler, sold by Radio Shack stores (if you can get it in Finland). Similar sprays are sold by most electronics suppliers.

If you can't get the error with the cover off, the next option is to try heating components until the error appears. This is a little tricky—too much heat will make good components look bad; a little more heat, and they stay bad. Be careful, and try not to heat anything above 70 degrees C (the maximum rated operating ambient temperature for commercial-grade ICs).

Table 1: *Null-modem connection for two computers with DB-25 connectors, or one with a DB-9 connector.*

Computer 1 DB-25	Computer 2 DB-25	Computer 2 DB-9
1	1	—
2	3	2
3	2	3
4	5	8
5	4	7
6	20	4
20	6	6

Concerning the Baby Blue Card, I don't know if it will work in the AT. PC expansion cards usually work in ATs, but the higher clock speed of the AT sometimes causes problems. Give it a try, and if you get errors, take it out.

A better method of reading files into the AT may be to use a utility program that temporarily changes one of your IBM disk drives to read CP/M formats. Two I came up with from recent ads are Uni-Form-PC from Micro Solutions, 125 South 4th St., DeKalb, IL 60115, (815) 756-3421, and Xenocopy from Xenosoft, 1454 Sixth St., Berkeley, CA 94710, (415) 525-3113.

Alternatively, you could use serial communications to transfer files between the two computers if you take Ozzy to work with you. All you need is a serial (RS-232C) port and a communications program in each computer to provide mechanics for copying files from one to the other. Many good programs are available at moderate cost, or for a special task like this, you could write a program in BASIC that would set up the serial ports and transfer the data. You don't need modems, although you could use them if you have them. All you really need is a null modem, which is a cable with two DB-25 (or possibly a DB-9 at the AT end), connected as shown in table 1. The pin 1 connection is probably not needed on DB-25 connectors, and there is no equivalent on the DB-9. —Steve

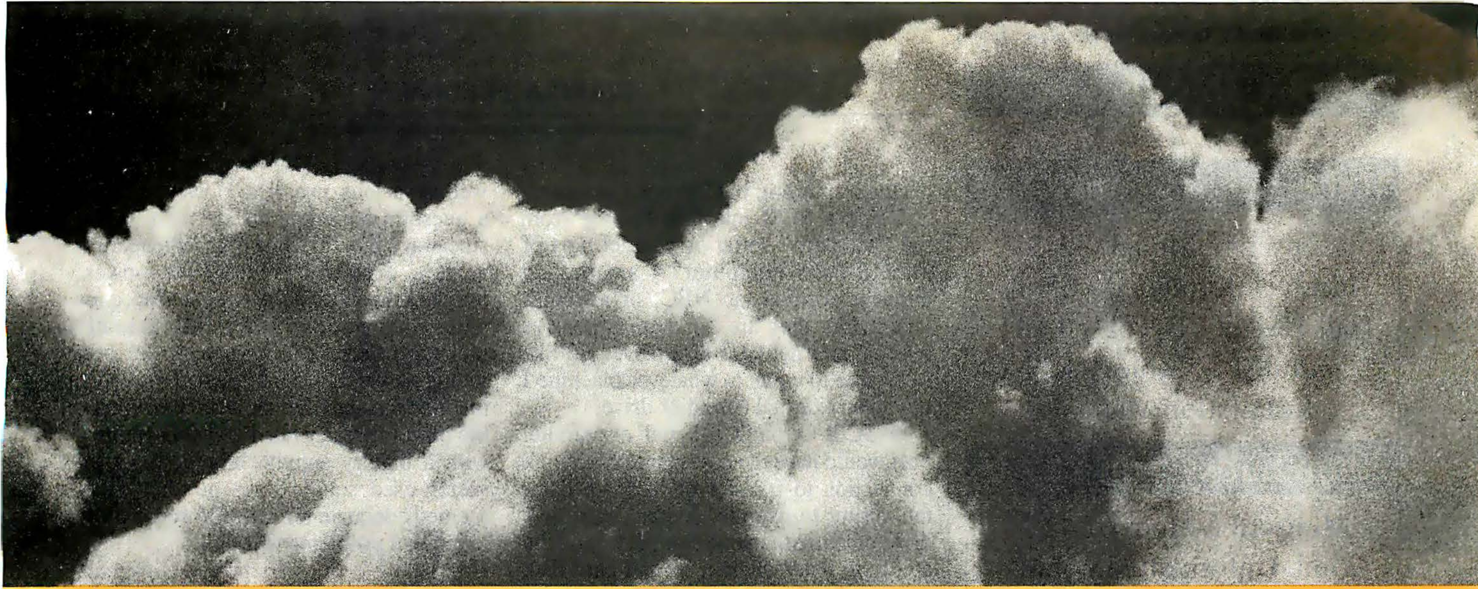
CIRCUIT CELLAR FEEDBACK

SCSI

Dear Steve,

As I recall, your single-board CP/M computer (the SB180) has a SCSI interface available. I know which end of a sol-

continued



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dering iron is hot, but I'm not a designer.

Could a SCSI interface operate from the "standard" serial or parallel port of an MS-DOS computer? I am buying either a Toshiba, an NEC, or a Zenith laptop, but they are far more expensive with an internal hard disk drive. I'd like to be able to connect whatever machine I buy to an external hard disk drive.

A SCSI through a serial or parallel port would have the advantages of a quick connection to transfer or back up data, the ability to use the external hard disk drive on more than one computer, and the ability to daisy-chain a second hard disk drive to the first.

I realize I would need a controller board for the hard disk drive. Any ideas?

Jim Martin
Tonopah, NV

The "standard" serial interface—more officially known as RS-232C—and the SCSI are quite different and totally incompatible. The RS-232C interface was originally intended for connecting modems to terminals and computer mainframes to allow users remote access to the systems. It is also used with adapters, called null-modem cables, to directly connect terminals to the host computer. The SCSI standard is commonly used in small computer systems (such as the SB180) to interface large disk drives and other intelligent peripherals.

Some portable machines, such as the Tandy 100, use a 3½-inch floppy disk drive connected via the computer's serial port. However, I am not aware of any large-capacity hard disk drives that use this technique.—Steve

Protect Me

Dear Steve,

From time to time, you have written about power protection for sensitive electronic equipment. I would appreciate it if you could review in a nutshell several areas of this topic.

First is the protection of 120-volt lines. You had recommended that the metal-oxide varistor with about a 130-V span produced by GE and others was adequate on protection across the hot lines to ground. However, what would be the best component to use as far as voltage span from the ground neutral line to the ground line? What other devices could be used for protection on these lines?

The second area for protection is serial-line communication. Several devices have been made available for protection on these lines. What would you recommend?

Finally, I am interested in constructing my own isolated power supply. High-capacity 12-V batteries are available, as well as various inverters. However, I have a question regarding square-wave versus sine-wave power. Most of the cheaper inverters produce square-wave power. Some of the more deluxe models produce sine-wave power. Does this actually make a difference in protection for providing power to the equipment? You once mentioned a gentleman who used a trip-lite power inverter in an overseas country with a battery supply. This type of inverter used square-wave power, and it seemed adequate for him. Do you see any long-term problems with this?

Nicholas J. Spagnola
York, PA

A future Circuit Cellar article will discuss many of your questions in detail. I will attempt some brief answers here, however.

The neutral (return) line in a normal household power system is nominally at ground potential. The fact that the line carries current, however, together with the resistance of the wires, causes a voltage drop in the return. Consequently, this line is somewhat above ground potential; how much depends on how far it is located from the nearest solid earth ground. The resistance in the wires also makes it possible for high-voltage transients to appear in the neutral line independent of the ground line. You can clamp these voltages by devices such as metal-oxide varistors and similar ceramic bilateral resistors (e.g., ZNRs and transorbs).

The voltage used for this device is not critical; it is usually convenient to use one of the same 130-V rms devices used to clamp the hot line. Other types of clamping devices include gas-discharge tubes, constant-voltage transformers, isolation transformers, and high-voltage zener diodes. The popular MOV-type ceramics are probably the most cost-effective in general use.

For protection of RS-232C lines, with maximum voltage swings of + −15 V, varistors with clamping voltages of 20 V to 25 V would be suitable. Each used RS-232C line should be clamped to pin 7 or to an external ground connected to the third wire of an AC outlet.

Telephone lines use ring voltages as high as 120 V, though 80 V or so is more common. A typical phone connection will use two signal wires, red and green in color. These lines should be clamped independently to ground with varistors that have voltage ratings slightly higher than the ring voltage. If you are unable to determine the ring voltage, you can use 130-V varistors like those used for AC power lines.

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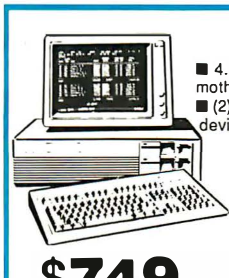
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Isolated power-supply design is a subject worthy of several books if thorough coverage is needed. No perfect solutions exist; each approach has virtues and drawbacks. Often, the simple square-wave inverters can be used with linear power supplies, but not with some switching types and some types of electric motors used in cooling fans, disk drives, and so on.

It is frequently not possible to determine which devices are compatible with square-wave power without long-term trials. In general, I would be wary of using any type of square-wave output supply with equipment designed for sine-wave power.

The price of sine-wave output constant-voltage transformers and uninterruptible power supplies, while once prohibitive, has now dropped to a level where buying one may be more economical than attempting to make one yourself. Check out the ads of suppliers such as Priority One Electronics and Jameco. These have the advantage of being compatible with any type of equipment designed for the same-voltage AC power.

If you can bypass the AC power input of the equipment entirely, you can run it directly from the DC output of the battery if you properly regulate the voltage.
—Steve

Interfacing with the Intelliwriter

Dear Steve,

Sharp claims that its Intelliwriter typewriter (model PA 1000H) will work as a printer for a computer. However, the Intelliwriter needs—you guessed it—an add-on RS-232C interface. Sharp is holding such a device hostage and will release one only for a multibuck ransom. Additionally, Sharp will not say if the interface will work with either the Toshiba T-1100 Plus or the NEC MultiSpeed. (I lust after both these computers with a possibly unhealthy passion.) Can you tell me if the Intelliwriter will work with either of the aforementioned laptop computers, assuming I acquire the RS-232C interface?

Since Sharp is asking so much for its interface, I'd like to cobble an interface myself or get one from a third-party supplier. Where could I get plans for an RS-232C interface? Or do you know of a third-party vendor that already has such an interface available?

Stan Foster
Sanibel, FL

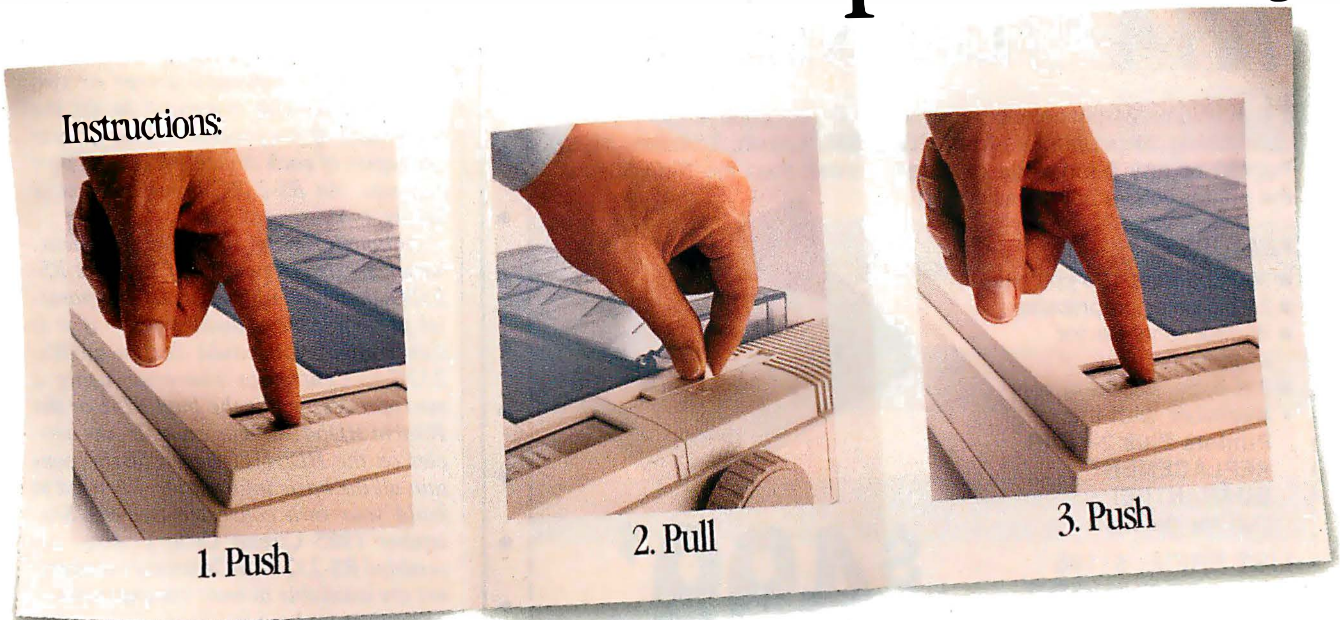
Though I could be wrong, I think it is reasonable to expect that an RS-232C interface for your typewriter would allow it to work with the T-1100 Plus, the Multi-

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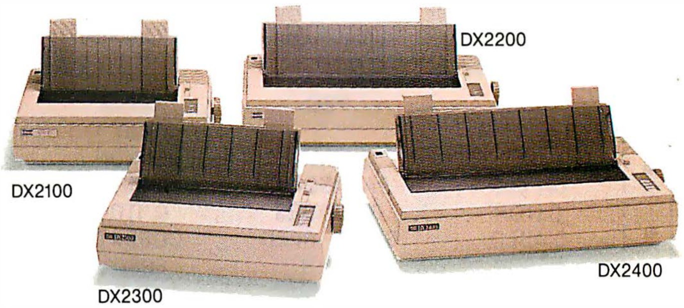
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Despite the fact that "RS-232C standard" is kind of an oxymoron (like "military intelligence" and "government service"), the worst it might take to get two RS-232C devices talking to each other would be a little fiddling with cables and setting a software driver or two (e.g., the MS-DOS *command to set the baud rate). If you proceed this way, try to get copies of each device's RS-232C port pin-outs. An RS-232C break-out box is handy, too.*

Although I'm not sure what the Intelliwriter's existing port is, if it is not RS-232C, then it is either a Centronics parallel port or a nonstandard port. If it is Centronics, you could design an RS-232C-to-Centronics converter using a microprocessor like the Intel 8751 or the Hitachi HD64180. For example, my articles on the HD64180-based SB180 contain all the basic information you need to build your own converter (see the September 1985 Circuit Cellar). Also, assembled RS-232C-to-Centronics converters are available at most computer stores or mail-order houses.

If the typewriter's port is nonstandard, the mandatory step before proceeding to build your own RS-232C-to-whatever is to get technical documentation that describes the typewriter's port signals, timing, and so on. However, the supplier may consider this information proprietary; if so, you are more or less locked into purchasing the company's interface.

A couple of cautions. Typewriter print mechanisms are often not up to the severe duty cycle of computer printing. Does the supplier have anything to say about this? Second, it is likely that your favorite word processor, and other software, may not have a driver that takes full advantage of your typewriter. You'd better ask the supplier what printer the typewriter emulates in terms of control codes, special functions, character sets, and so on.
—Steve ■

Between Circuit Cellar Feedback, personal questions, and Ask BYTE, I receive hundreds of letters each month. As you might have noticed, in Ask BYTE I have listed my own paid staff. We answer many more letters than you see published, and it often takes a lot of research.

If you would like to share your knowledge of microcomputer hardware with other BYTE readers, joining the Circuit Cellar/Ask BYTE staff would give you the opportunity. We're looking for additional researchers to answer letters and gather Circuit Cellar project material.

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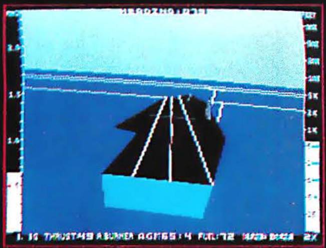
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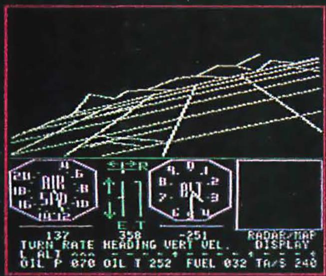
1986 - Flight Simulator II for the 68000 computers



1985 - High-performance Jet flight simulator for the IBM, Commodore 64, and Apple II computers



1982/1983 - Microsoft Flight Simulator & Flight Simulator II



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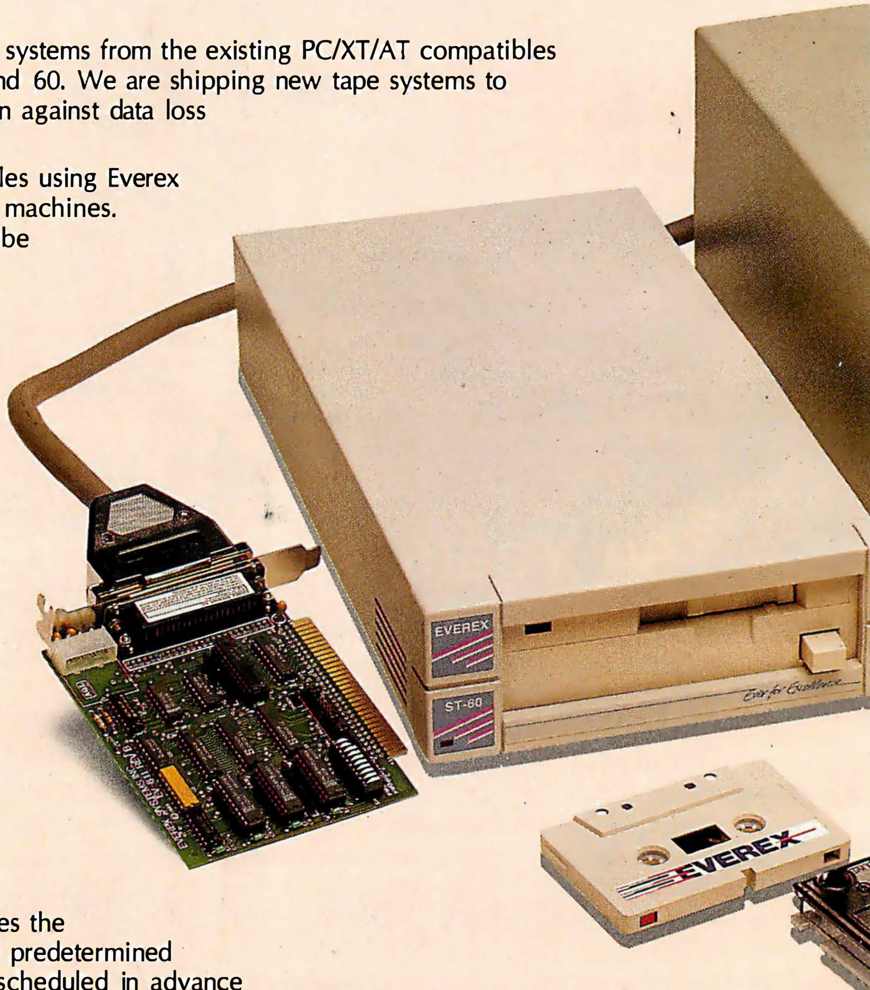


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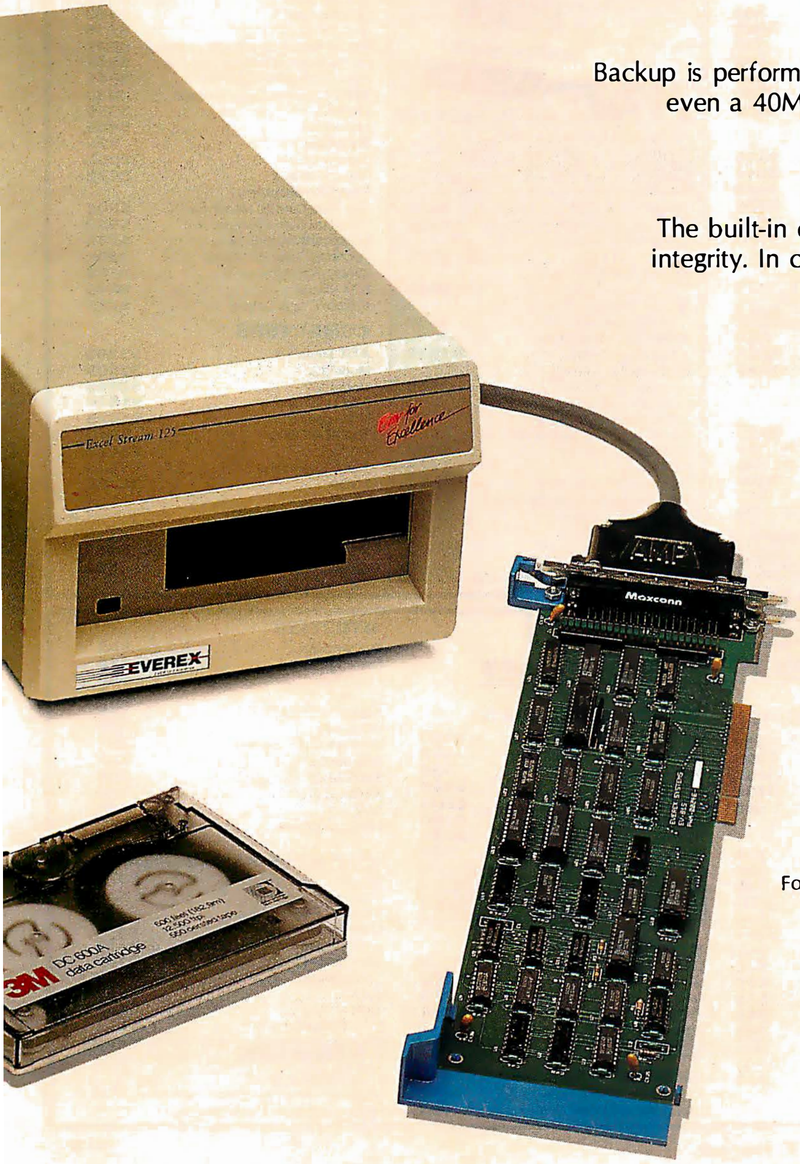
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C: A REFERENCE MANUAL, 2nd ed.
Samuel P. Harbison and Guy L. Steele Jr.
Prentice-Hall
Englewood Cliffs, NJ: 1987
ISBN 0-13-109810-1
404 pages, $31

MICROCOMPUTERS AND PHYSIOLOGICAL SIMULATION, 2nd ed.
James E. Randall
Raven Press
New York: 1987
ISBN 0-88167-292-0
287 pages, $32

TEX FOR SCIENTIFIC DOCUMENTATION
Jacques Désarménien, ed.
Springer-Verlag
New York: 1986
ISBN 0-387-16807-9
198 pages, $19.80



C: A REFERENCE MANUAL
Reviewed by John Unger

Sometimes a reference book gets to be known by its author's name rather than by its title. This honor was bestowed upon the first edition of *C: A Reference Manual* by those in the C language programming community, where the book is often referred to as simply Harbison and Steele, or H and S. While other reference books on the language cover aspects of C as related to specific computer systems or with respect to specific applications, *C: A Reference Manual* provides an in-depth view of C's many gray areas and addresses problems in syntax and structure of which few C programmers are aware.

Samuel P. Harbison and Guy L. Steele Jr. concentrate on giving a precise description of the C language. The book grew out of their effort to write a family of C compilers that would handle the same source-code programs identically on different computers—as far as hardware differences would allow.

C: A Reference Manual is not the kind of text you can read from cover to cover. The authors write in a rather dry, academic style; you'll keep the book next to your compiler manuals rather than at your bedside.

A Little Reminder
As a relative newcomer who has been actively writing C programs for about 5 years, I frequently come across aspects of the language that I don't know how to implement into my programs properly. The C language conference on BIX can be a big help, but what you need is not always available when you need it. That's when *C: A Reference Manual* becomes indispensable. I found that I could rely on it to give me an in-depth description of even the more arcane aspects of C. For example, I had written a fairly simple C program to manipulate some floating-point numbers. The program included such statements as

```
depth = 2.87;
      .
      .
      .
velocity = 6.15;
```

where depth and velocity were declared as floating-type variables. This program compiled and ran perfectly using Microsoft C version 4.0, but when I compiled it with the option `/W2`, which sets the warning level at 2 to catch automatic data conversions and missing returns in function definitions, I found the message `warning 51: data conversion`. I couldn't figure out what the problem was until I found in Harbison and Steele that in C all floating-point constants (e.g., the values 2.87 and 6.15 in the statements above) are always type double. The compiler was telling me to be aware that I had mismatched types.

Handy Numbering Systems
The book uses a systematic notation for each of its sections. For example, Chapter 5, entitled "Types," has a major section, 5.3, "Pointer Types," which in turn has its own subsection, 5.3.1, "Pointer Arithmetic." This type of organization makes it easy to find material in the book.

The authors make the process even more helpful by listing other pertinent references to the subject matter at the end of each subsection. For example, at the end of subsection 5.3.1 is a series of references: "addition operator 7.6.2; assignment operators 7.9; conversion to pointers 6.2.7," and so on. The numbering system makes this cross-referencing easy to use and prevents you from having to flip back and forth to the index. It also means that you can start reading almost anywhere in the book;

continued

Illustrated by Les Kanturek

using the cross-references, you can refer to previous sections pertaining to the subject matter.

Proposed Standard

An important chapter describes the Draft Proposed ANSI C standard and how it differs from the implementation of C described in the rest of the book. Because the sections in this chapter use the aforementioned numbering system, they provide ready references to the original subsection where the feature of ANSI standard C being discussed was first described.

The text focuses on the use of the C language in its fully implemented form found on Unix systems, but it does not emphasize features of the language that are specific only to Unix. One aspect of the book that sets it apart from other references to the language is its description of "standard libraries" that have become part of the language on Unix and that are included in some form in compilers found on other operating systems, such as MS-DOS. Nearly 100 of the book's 404 pages are dedicated to descriptions of the library functions.

Because the book also describes the draft proposed ANSI C standards, the chapters on the standard C library functions clearly indicate which library functions currently used are either not part of the draft proposed ANSI standards or are implemented somewhat differently in those standards.

C: A Reference Manual lives up to its advertisement as a complete treatise on C written with an emphasis on being up to date. It includes the best description of the Draft Proposed ANSI standards integrated with normal C that I have seen. It is certainly not required reading for someone just starting to learn C, but I would recommend it to all serious C language programmers.

John Unger (P.O. Box 95, Hamilton, VA 22068) is a geophysicist who uses computers to study the structure of the earth's crust in earthquake-prone regions of the eastern U.S. He can be contacted on BIX as "reviews2."

MICROCOMPUTERS AND PHYSIOLOGICAL SIMULATION

Reviewed by Karl S. Wittman

Are computer simulations worth the effort? In *Microcomputers and Physiological Simulation*, James E. Randall elegantly demonstrates that good instructors cannot afford to overlook this teaching tool. His purpose is not to hand over ready-to-run computer programs, but rather to show instructors how to build their own software. In doing so, Randall has written a primer of concepts, techniques, and examples for microcomputer users to adapt to their own particular applications. The author's subject, quantitative physiology, is tailor-made to illustrate the way in which teachers can make the transition from using mechanical models and analogies to creating and using computer models of complex living organisms.

Simulations and Education

While educators find microcomputers an attractive supplement to traditional didactic strategies, many are not aware of the significant potential of computer simulations. Publication of commercial discovery-based software, with its emphasis on student control of the learning process, has begun to stimulate interest in simulations. Students can more clearly visualize complex interactions, and teachers can produce what Randall calls "dynamic illustrations" of phenomena not normally possible in the classroom.

Even if teachers want to use computer simulations, there are

continued

few quality software products available, and those may not target a teacher's specific requirements. As Randall points out, the most effective simulations are likely to be personally developed by a teacher, since these programs spring directly from specific instructional needs and teaching style.

BASIC as a Simulation Language

Randall uses BASIC, as implemented on MS-DOS personal computers, to develop his simulation software. In his view, BASIC is adequate for most models that teachers will prepare, although he concedes that extensive simulations with large memory needs and procedural structures will require a more sophisticated language. Nevertheless, the author maintains that BASIC can produce highly structured programs, and he guides readers through the development of subroutines emphasizing disciplined use of branching operations, data types, and user-defined functions.

Computer simulations are useful only if students find them easy to operate and understand. Randall contends that graphics-based software can achieve these goals. Microcomputers make graphics programming accessible because BASIC has built-in color graphics extensions. With little additional training, a programmer can add a more realistic representation of physical phenomena. Moreover, when you connect the computer to a dot-matrix or laser printer, a hard copy of the screen can be quickly put in the student's hands.

The book contains many programming techniques illustrated by actual applications to physiological phenomena. For example, Randall shows how to combine `VIEW` and `WINDOW` commands to plot a typical Henderson-Hasselbach equation in which pH is expressed in terms of arterial partial pressure of carbon dioxide and arterial bicarbonate concentration. The `VIEW` command is used to select a portion of the monitor screen on which to display the plot, and the `WINDOW` command sets the plot scale.

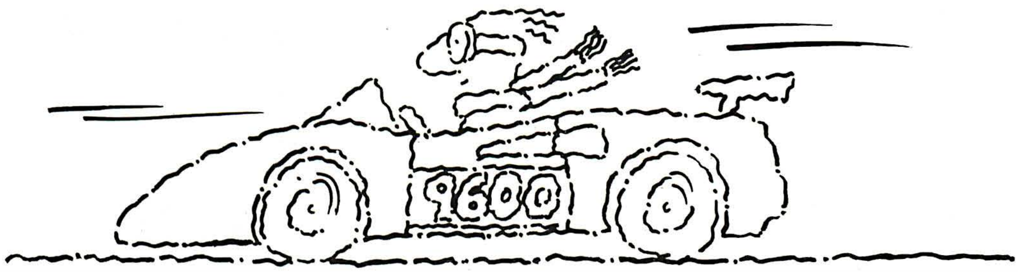
Randall takes considerable care to guide the reader through each component of a simulation. For example, he not only provides code for a complete plot subroutine, but he also thoughtfully suggests sources for adapting this and other subroutines to the reader's own work. In fact, one of the book's strong points is its provision of relevant and recent references following each chapter.

Microcomputers and Models

Randall's book focuses on the development of a satisfactory computer simulation as a two-part process: formulation of a mathematical model that accurately describes the physiological mechanism, and successful translation of the model to a computer program. Simulation programmers are acutely aware of the problems involved in converting mathematical concepts to the discrete computational methods of the computer. While transfer from the precision of algebraic expression to the approximation of digital computations harnesses the brute-force ability of the computer to perform repetitive calculations, this same iterative process can introduce serious computational errors and distortions.

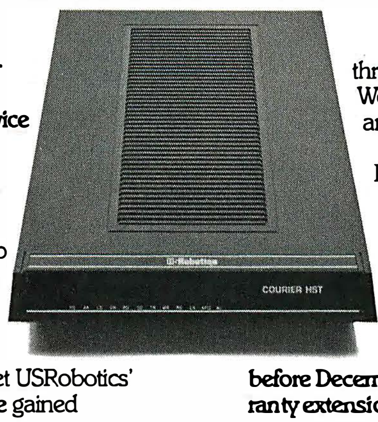
Randall is especially cautious about advising novice programmers of the traps to which they might fall prey. For example, he is clearly aware of the trouble microcomputers have with truncating and rounding numbers, and he shows his readers how to minimize these problems. He also takes care to point out that simulations of continuous physiological processes can be approximated by solutions of mathematical iterations only at finite periods of time. When these values are plotted graphically on the CRT screen, he says, "The honest thing to do is to place a point indicating the value of the solution at each time position."

continued



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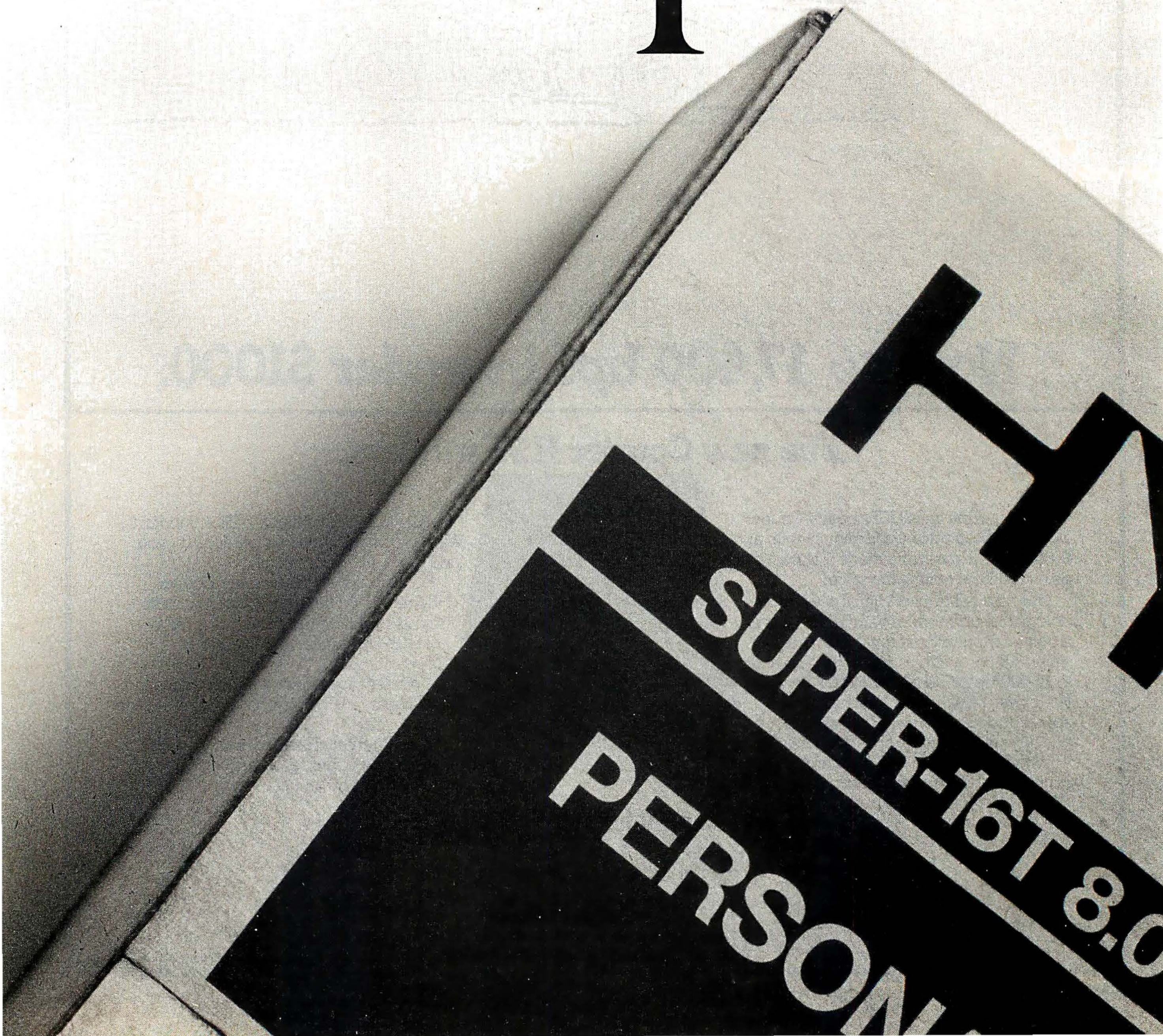
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He illustrates the method using the PSET command.

A valid physiological model should fully reflect actual values that might be expected in a living system. Often, functional relationships are mathematically nonlinear and can be more difficult to reproduce as a simulation than as a simple linear solution. Randall considers various mathematical alternatives to approximating real physiological systems while showing the reader his approach to optimizing the processing speed and accuracy of the formulations.

An Example of Model Development

A nephron is the basic structure in the kidney that concentrates nitrogenous end products of protein digestion and eliminates these wastes as urine. Randall's model of the process of producing urine takes into account the biological mechanisms that allow molecules to selectively cross cell membranes, the regulation of local osmotic pressure gradients, and the action of antidiuretic hormones on nephron-collecting duct permeability. His model also permits the student and teacher to manipulate such variables as blood plasma osmolarity, molecular filtration and transportation rates, and cell membrane permeability values.

Randall's approach to this simulation is typical of the way he handles the task of describing various models he uses in his own teaching. He believes that clear conceptualization of the physiological phenomenon leads to a precise mathematical statement of the model. He provides the reader with a broad view of the model, describing each important variable followed by consideration of characteristic relationships between and among the variables as expressed in mathematical terms.

A Valuable Sourcebook

Microcomputer and Physiological Simulation is a valuable sourcebook of ideas and techniques for teachers who are willing to put some effort into writing their own simulation software. Although the book is directed toward quantitative physiology, teachers of any subject with mathematically describable phenomena might benefit from it. I particularly like the author's writing style. Despite the very technical nature of the book, Randall expresses himself clearly, precisely, and in a personal way so that I almost felt as though I was getting a one-on-one tutorial.

It may appear contradictory that the only substantive fault I find with the book is also one of its chief virtues. Randall's intent is to help teachers who are new to programming and to simulations. In doing so, he does not provide full program listings but uses his book as a vehicle for demonstrating the process from concept through validated simulation.

I recommend *Microcomputers and Physiological Simulation* to anyone seriously interested in learning about computer simulation as a practical educational tool.

Karl S. Wittman (8 Reid Place, Delmar, NY 12054) is a technical writer who covers the allied health and education fields as affected by computer technology.

TEX for Scientific Documentation

Reviewed by Alan Hoenig

The public domain typesetting program TEX is one of the more interesting pieces of software floating around. Given form by Donald Knuth of Stanford University, TEX is capable of far more versatility and virtuosity than just about any other typesetting system, whether driven by computers or operated by humans.

Devotees of TEX in this country form a small but enthusiastic

continued

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- Symbol libraries with more than 500 symbols are included at no extra charge.
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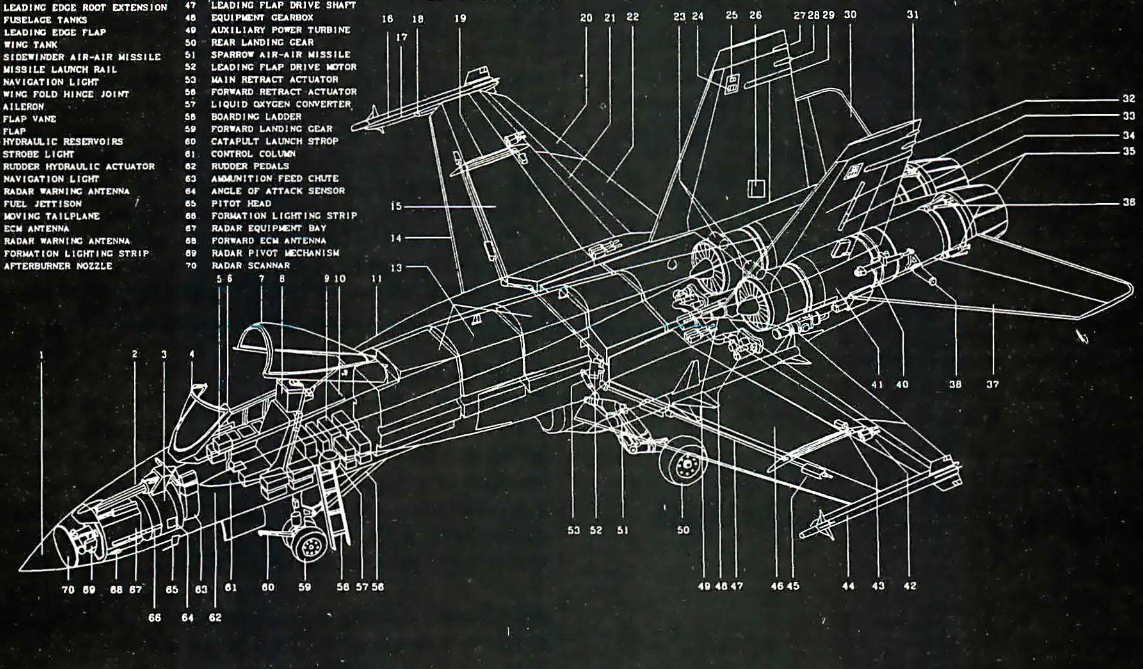
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69 RADAR PIVOT MECHANISM
70 RADAR SCANNAR

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group that operates along informal lines. Our European counterparts are far more structured, and hence we have TEX *for Scientific Documentation*, the proceedings of a second European conference devoted to TEX.

Some Disappointments

Lots of interesting papers appear within this volume of proceedings, but there are some disappointments. For example, the book's title, while wholly accurate, is entirely misleading. Despite the stated theme, the conference planners seem to have accepted papers concerned with any aspect of TEX. Only two or three papers (out of 16) address the title TEX *for Scientific Documentation*. Rather, it is TEX's idiosyncrasies that seem to have set the de facto theme for this meeting. Focal points include the fact that TEX is not WYSIWYG (what you see is what you get) and is batch-oriented. Second, because of TEX's unique nature, it takes a competent programmer to achieve fancy effects. Finally, can TEX work with non-English text? Based on the spirit of these papers, the conference should have been titled "Nonstandard TEXnical Environments."

Most of these papers describe front ends, back ends, interactive shells, and what have you that fit over, on top of, or under TEX to make TEX work in a friendlier or easier way. And here's another disappointment: Some papers fail to distinguish between work contemplated, work in progress, and work completed. Occasionally, it is unclear precisely at which workstation or microcomputer these implementations are aimed. Finally, and most frustrating, is the lack of information about the availability of the software; how can we in the U.S. get our hands on this stuff? Some of the packages sound good (and work quite well, or so I understand from attendees of the meeting). But reading these proceedings is like leafing through a catalog from which all prices and ordering information have been excised.

My final negative comment—and one that I'm not sure is even fair—pertains to the uneven quality of the writing. Many of the papers read just like documentation. Although English was the official language of the meeting, it is clearly not the native language of many contributors.

What TEX Can Do

Nevertheless, if you are TEXnically-oriented, you will be pleased to dip into this book. You will want to know what kind of work is being done with TEX to make it work in ways presumably not intended by its creator. For example, EasyTEX, a product of Milanese scientists, provides a series of menus from which you create equations for your document. The equation will appear on-screen as you specify it, while genuine TEX code is generated behind the scenes.

Another example: When running the University of California at Berkeley's VORTEX system, you see your source text and previewed typeset copy on separate windows on your monitor. You can edit either window, and changes from one automatically propagate to the other. (Is this true on-line TEX?)

Good Quality

A problem with other proceedings—but not this one—is the poor quality of the printed page. Typescripts are usually collected and photographed for printing as is, and sometimes the sacrifice of professional appearance for speedy communication is a reasonable one. Fortunately, all the authors prepared their papers using TEX, and the result is a volume characterized by a uniform and professional appearance. ■

Alan Hoenig (17 Bay Ave., Huntington, NY 11743), a professor of mathematics at John Jay College of Criminal Justice in New York, is a TEX *consultant.*

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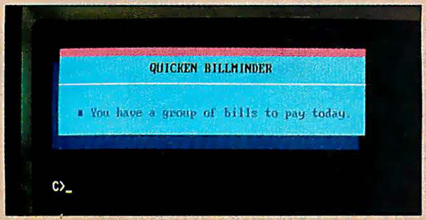
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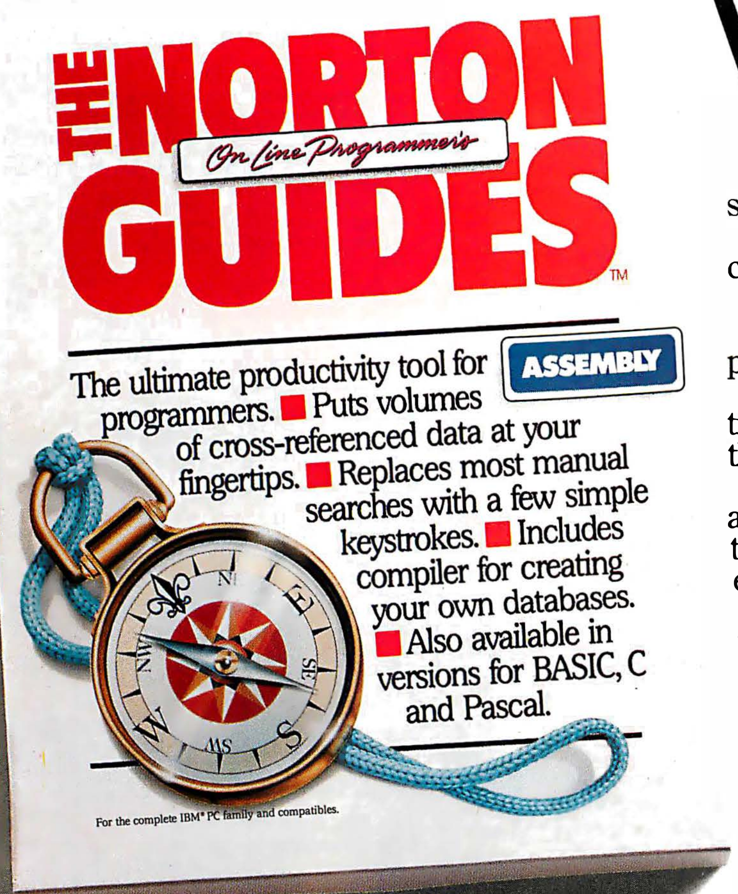
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Nobody ever said programming PCs was supposed to be easy.

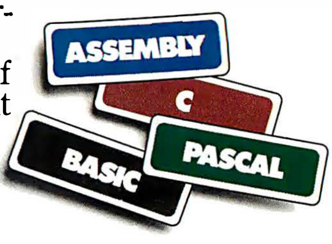
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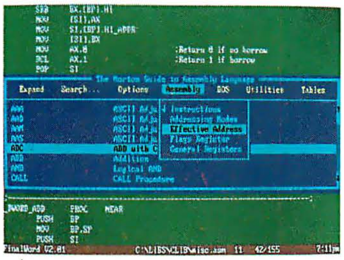


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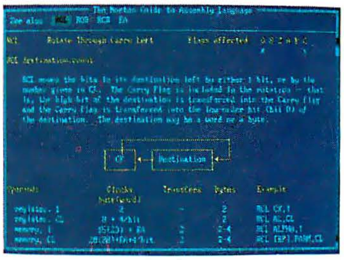
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Boosts productivity with easy to read character set and advanced ergonomics.	Likewise.
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At $599, the Wyse WY-60 delivers unrivaled value if you're looking for sharp resolution, advanced features and superior overall quality in an AT-compatible alphanumeric terminal.	At $649, the Wyse WY-99GT delivers likewise in a graphics terminal, with Hercules and IBM CGA compatibility.

So if you're looking for the best terminal to turn your AT into a multi-user system, there's really no choice like Wyse. For more information, call 1-800-GET-WYSE.

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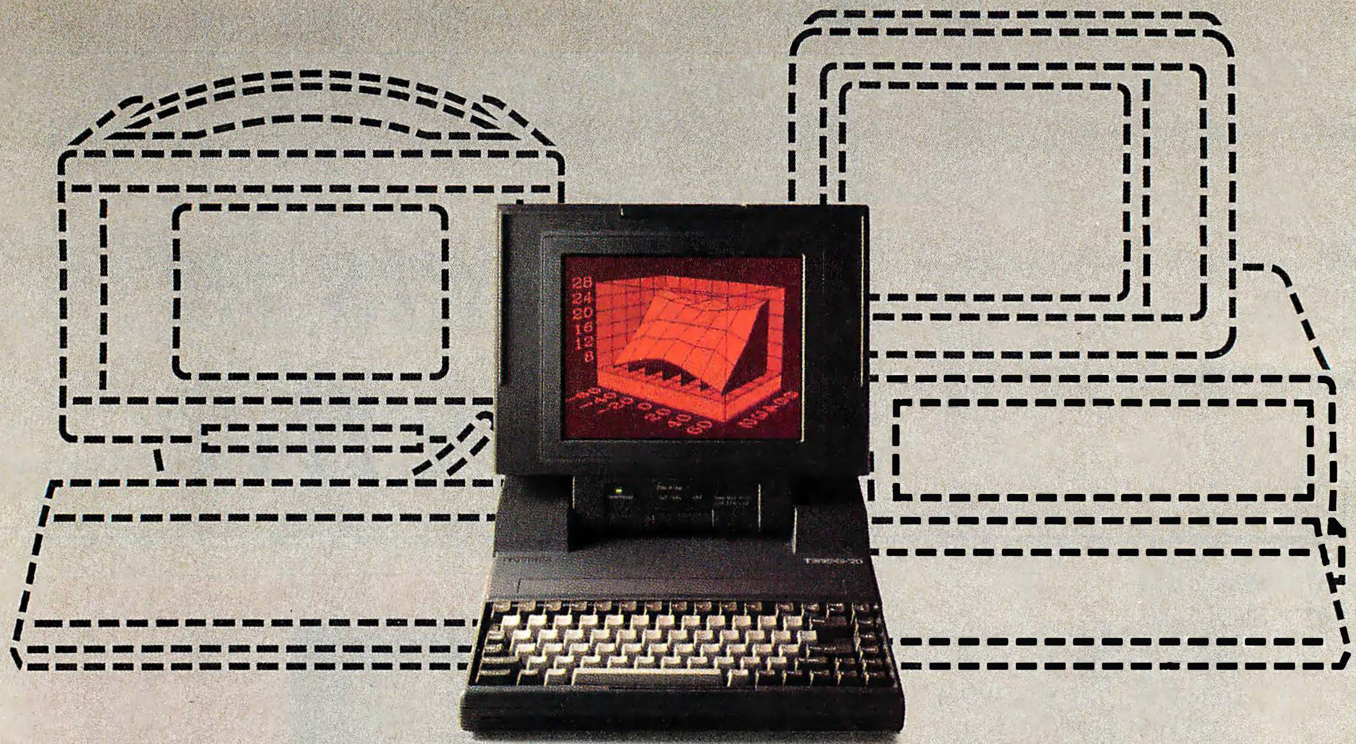
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New Portable from HP

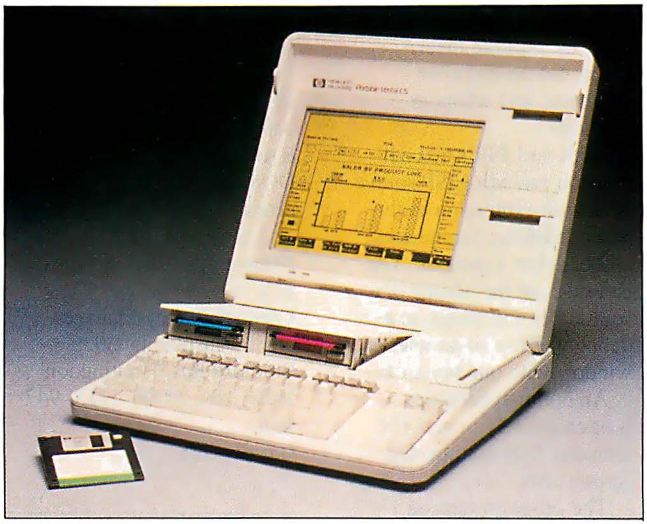
About the size of a standard attache case, Hewlett-Packard's new IBM PC-compatible Portable Vectra comes in models both with and without a hard disk. The Vectra measures 16.5 by 13.9 by 3.5 inches and weighs 16.6 pounds with its rechargeable battery module.

The unit's flip-up cover has a full-size 12-inch diagonal supertwist LCD screen that displays 80 characters by 25 lines. It is CGA-compatible with a resolution of 640 by 400. Besides having continuously adjustable contrast and tilt, you can detach the Vectra screen and hook the computer up to any external, MDA-, CGA-, or EGA-compatible monitor.

Based on a CMOS 8086-compatible processor running at 7.16 MHz, the system has a socket for an 8087 numeric coprocessor and includes 640K bytes of RAM, expandable to 6 megabytes (up to 4 megabytes in the hard disk-equipped model).

The Vectra has a full-size 92-key keyboard with full-travel keys. It comes with either two 3½-inch 1.44-megabyte floppy disk drives, or with a single floppy drive and a 20-megabyte hard disk drive. HP says the floppy-only model of the Vectra will run up to 10 hours on battery, the hard disk model up to 4 hours.

The Vectra comes standard with a parallel port, but no serial port. Options include a dual-serial EMS adapter, both 1200-bps and 2400-bps modems, and HP Vectra DOS 3.2, which the company claims is functionally equivalent to DOS 3.3.



HP's Portable Vectra is the size of an attache case.

Price: $2495; with 20-megabyte hard disk, $3595; dual-serial EMS adapter with 1 megabyte, $995; with 2 megabytes, $1795; 1200-bps modem, $450; 2400-bps modem $695; Vectra DOS 3.2, $95.
Contact: Call your nearest Hewlett-Packard dealer. To obtain the phone number, call (800) 367-4772.
Inquiry 751.

Color Graphics Page Processing

PagePerfect is a word-processing-based page processor from International Microcomputer Software Inc. (IMSI) that includes a file-management shell. The operating shell lets you create a document, integrate graphics, lay it out, compose, and print it without leaving the program. The program is keyboard-controlled, with function keys used to control procedures like create, change, view, move copy, go to, and undo. Using a virtual-memory scheme, undo enables you to erase the last function you performed.

The program is mnemonic, so you can type just the initial letter instead of a full command. A menu is always visible at the top of the screen, showing you where you are in the layout.

You can enter and edit text within a composed page at nine view levels. The program emulates WordStar and MultiMate and can accept files from many other word-processing programs. The program comes with style sheets that include memos, business letters, invitations, announcements and reports, or you can create your own. You can save style sheets and scroll through them, forward or backward, to find the one you want.

The program has over 100 typefaces, and supports bold, italic, bold italic, underline, double-underline, reverse, outline, and strike-out. It also supports multiple gray shades and patterns for text characters and backgrounds.

A graphics editor, Desktop Publisher's Graphics, is bundled with PagePerfect. The program lets you scan images into PagePerfect, or you can import them from other graphics programs. You can also draw, edit, crop, or enhance pictures without leaving the program. PagePerfect's Image Librarian is an indexed picture file that you can use to call up images by name or scroll through thumbnail sketches, choose the one you want, and position it in your document.

Houghton-Mifflin's spelling checker and thesaurus are also included in PagePerfect. It also includes incremental-refresh capability, which means that while it is a WYSIWYG (what you see is what you get) editor, the screen only refreshes when you pause, rather than moving back and forth every time you make a change, which can be distracting, according to IMSI.

With PagePerfect you can create documents of any length, limited by available memory.

Only the version for color monitors will be shipping at first. IMSI reports that a monochrome version will be available in the future.

PagePerfect runs on IBM PC ATs and compatibles with at least 640K bytes of RAM, a hard disk drive, an EGA, and a color monitor.
Price: $495.
Contact: International

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Microcomputer Software Inc., 1299 Fourth St., San Rafael, CA 94901, (415) 454-7101.
Inquiry 752.

New Technology Printer

Data Technology Corp.'s CrystalPrint VIII page printer uses Casio's new liquid-crystal-shutter-technology print engine, along with DTC's custom printer controller. The 8-page-per-minute printer emulates the HP LaserJet Plus, and includes 1.5 megabytes of RAM for full-page graphics capability on both letter and legal-sized paper. It also has nine ROM-resident type fonts.

The liquid-crystal-shutter technology keeps both pixel size and light source/drum clearance uniform, resulting in sharper, undistorted characters. The CrystalPrint VIII's organic photoconductor drum provides up to 7000 pages before replacement, and the separate toner set will do up to 5000 pages.

Options include Epson, Diablo, HPGL, and IBM Pro-Printer emulation cartridges, as well as various font cartridges.
Price: $2495.
Contact: Data Technology Corp., 2551 Walsh Ave., Santa Clara, CA 95051, (408) 727-8899.
Inquiry 753.

muLISP-87

Added to the 87 version of muLISP is a window manager that assists you in writing menu-driven interfaces for applications programs, primitives for high-resolution graphics, and utility libraries that implement multidimensional arrays, record structures, and dynamic closures.

A LISP-based programming environment, muLISP includes more than 450 Common LISP functions and special forms, a library of utility programs, and a screen-oriented editor and debugging system. A Flavors package features multiple inheritance, before and after daemons, and whopper methods.

With muLISP's text editor, you can edit LISP source files with expression-evaluation, blinking-parentheses, and undelete functions. You can suspend the editing of a source file and switch to a debug window or another edit window with one keystroke.

An optional compiler written entirely in muLISP includes fully commented source code.

The program runs on IBM PCs and compatibles with MS-DOS or PC-DOS 2.0 or higher and 256K bytes of RAM. It also runs on IBM PS/2s and is available on 5¼- and 3½-inch floppy disks.
Price: $250; compiler, $150.
Contact: Soft Warehouse Inc., 3615 Harding Ave., Suite 505, Honolulu, HI 96816, (808) 734-5801.
Inquiry 754.

Calculating Your New Withholding

EasyForm W-4 calculates the number of your allowances, the resultant amount withheld from pay, the government-suggested additional withholding, and any adjustments required during the year for the W-4 Employee Withholding Certificate to meet government requirements. In addition, the program calculates the permissible amount for an IRA, eligibility for special withholding allowance, allowable amount for itemized deductions, and any additional standard deductions for employees or spouses not itemizing, blind, or over 65 years of age. It also calculates adjustments to income and the impact of phase-in rules (e.g., losses from business or investments, qualified contributions to IRA or Keogh plans, and others based on the new Tax Reform Act). One version of the program runs on Lotus 1-2-3 (any release); the other is a stand-alone version with Lotus-like menus.

EasyForm W-4 runs on IBM PCs, XTs, ATs, and compatibles with 256K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher. The program comes on either 5¼- or 3½-inch disks.
Price: $49; yearly updates, $19.
Contact: Valley Management Consultants, 3939 Bradford Rd., Huntingdon Valley, PA 19006, (215) 947-4610.
Inquiry 755.

Weibull Probability Analysis

WeibullSMITH is a probability-analysis program that uses a technique developed by Wallobi Weibull. The program handles normal, exponential, log-normal, and skewed-normal distributions. You can plot up to three sets of data and their associated confidence limits on the same graph with up to 250 points in each data set. The program supports CGA- and EGA-compatible graphics and is compatible with Fulton Findings' PlotSMITH program. Files use the ASCII format. A conversion program changes Lotus 1-2-3 .PRN data files to the WeibullSMITH format and vice versa. The program automatically scales data values in increasing order, determines their median rank values, and plots and interprets results.

WeibullSMITH runs on IBM PCs, XTs, ATs, and compatibles with 256K bytes of RAM, EGA or CGA graphics, MS-DOS or PC-DOS 1.0 or higher, and an IBM-compatible printer.
Price: $59.
Contact: Fulton Findings, 1251 West Sepulveda Blvd., Suite 800, Torrance, CA 90502, (213) 518-5045.
Inquiry 756.

Analytical Modeling of Manufacturing Systems

Manuplan II, a Lotus 1-2-3 add-on, is designed for managing the manufacturing process from the global perspective down to the individual user. The program is based on mathematical simulation, rather than Monte Carlo.

To run an analysis, you can input minutes, days, years, and utilization limits as macros. You can also insert numbers for failure and repair, setup time, and the time needed for each piece to be manufactured. The program also lets you choose what machines to use, and what proportion of the work is assigned to which machine.

It takes between 15 and 45 minutes to get answers to typical problems. In responding to the model you set up, it will tell you if it's feasible, how much you'll produce, how much you'll scrap, and so on.

This information enables you to then analyze how productively the time is being used. Then you can make changes in your model, based on the charted setup, runtime, and downtime.

Manuplan II runs on IBM PC ATs and compatibles with a color monitor, 640K bytes of RAM, MS-DOS or PC-DOS 2.01 or higher, and Lotus 1-2-3 version 2.0 or higher. You also need a hard disk drive with at least 2 megabytes of free space, a parallel port, and a 1.2-megabyte floppy disk drive.
Price: $3500.
Contact: Network Dynamics Inc., 1218 Massachusetts Ave., Cambridge, MA 02138, (617) 547-2036.
Inquiry 757.

continued

High-Performance Graphics System

Raster Technologies Model One/385 system uses a proprietary IEEE floating-point processor architecture optimized for execution of complex two and three-dimensional algorithms. The architecture provides graphics performance capabilities of up to 140,000 3D vectors per second.

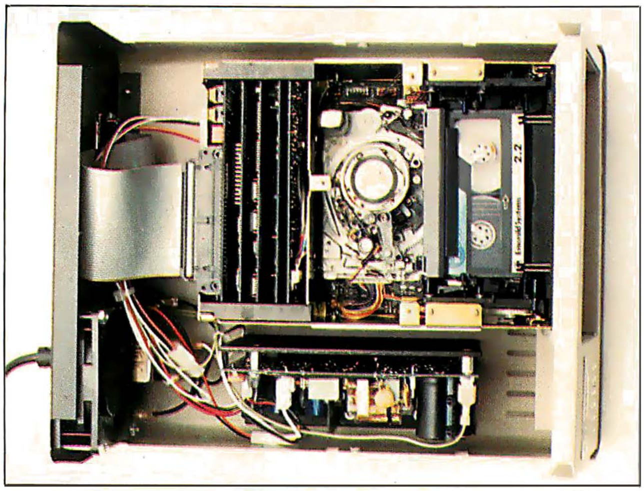
The system has 1280- by 1024-pixel resolution, supports eight local light sources, and up to 16.7 million displayable colors. Its 32-bit display processor performs coordinate transformations, Gouraud shading, and hidden-surface removal, while freeing the system's main processor for other activities.

System options include 8 to 24 bits of image memory, double-buffering support for multiple independent displays, 8-bit image overlays, and Genlock. Two-bit text overlays, which allow text and multiple cursors to function independently of graphics, are standard.
Price: Starting at $33,000.
Contact: Raster Technologies Inc., Two Robbins Rd., Westford, MA 01886, (617) 692-7900.
Inquiry 760.

VCR Technology Tape Backup

Using helical-scan recording technology similar to that used in videotape recorders, Emerald Technology's VAST (virtual archive storage technology) device backs up hard disks, CD-ROMs, and other high-capacity storage devices at up to 15 megabytes per minute.

VAST cassettes are available in sizes that hold 250 megabytes, 500 megabytes, 1 gigabyte, or 2.2 gigabytes (the equivalent of about 6200 floppies or 1 million sheets of paper). And for those with truly horrendous backup needs, VAST devices can be linked together for total capacities of over 15 gigabytes.



The VAST device uses VCR-like technology to back up data.

The VAST device uses sophisticated error-correction techniques and, according to the company, will correct erroneous data bursts of up to 264 bytes, and 80 additional random errors in each 1024-byte block of data.

Software shipped with the VAST device includes Emerald's Archival Storage Protector, a menu-driven tape-management utility that lets you back up all files, selected files, selected directories, or just files changed since the last backup.

Measuring 16 by 14 by 8 inches and weighing 15 pounds, the VAST device comes with a 5-foot cable and a half-length SCSI controller board that plugs into any PC or compatible expansion slot.
Price: Starting at $6995.
Contact: Emerald Systems Corp., 4757 Morena Blvd., San Diego, CA 92117, (619) 270-1994.
Inquiry 758.

Low-Cost LaserJet Expansion

1-2-4 isn't a variation of a popular spreadsheet program; it's an add-in board that provides 1, 2, or 4 megabytes of expansion memory for Hewlett-Packard's popular line of LaserJet series II laser printers.

1-2-4 is available as an unpopulated board, or loaded with 1, 2, or 4 megabytes, in 150-nanosecond chips. No special tools are needed for installation. All you need to do is remove the printer's cover, set the switches on the memory board, and plug the board into the LaserJet memory slot.
Price: Unpopulated, $295; 1 megabyte, $395; 2 megabytes, $895; 4 megabytes, $1595.
Contact: Pacific Data Products, 8525 Arjons Dr., Suite M, San Diego, CA 92126, (619) 549-0922.
Inquiry 762.

Multitasking on a Mac

MultiFinder lets you view multiple applications concurrently and copy, paste, and move between applications within the Macintosh environment. With the necessary hardware, MultiFinder enables you to work in and integrate information between multiple operating systems.

Using the standard Macintosh user interface, you can select from active applications in the Apple menu, click in the desired application's window, or double-click its icon in the desktop. An icon in the upper-right corner of the screen shows the application that's currently running. You can have up to 30 applications open at once, limited only by the amount of RAM available.

MultiFinder runs on all Macintosh II, SE, and Plus systems with at least 1 megabyte of memory.
Price: $49.
Contact: Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014, (408) 996-1010.
Inquiry 759.

80386 Operating System

Executive for the 80386 is a board-level, ROM-able, real-time, multitasking operating system that supports 12 CPU architectures including Intel's 8088, 8086,and 80286, Zilog's Z80, and Motorola's 6809, 68000, and 68020. It is written in C, except for time-critical sections such as context switching, task scheduling, and interrupt handling, which is written in assembly language. C Executive's call mechanism doesn't require programs in C to use hardware traps or interface libraries. And CE-FILE, an optional file system, is also available in an 80386 version.

C Executive runs on the IBM PC XT or AT with an 80386. The binary package includes MetaWare's C compiler, and Phar Lap's assembler, linker, and librarian.
Price: $575 for binary package; $5000 for source code; $250 for optional file system.
Contact: JMI Software Consultants Inc., 904 Sheble Lane, P.O. Box 481, Spring House, PA 19477, (215) 628-0846.
Inquiry 761.

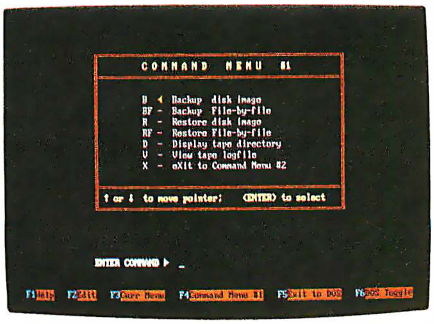
continued

THE RIGHT ANSWER TO THE BACKUP QUESTION



NOW IT'S EASY, FAST, AND AUTOMATIC

The software in Genoa's Galaxy™ tape system makes backup easy and fast. Just choose your options from the menu, press a few keys, and four minutes later your 20 MB hard disk is all backed up.



SMART, AUTOMATIC

You can set your Genoa Galaxy to backup automatically on a regular basis—like once a day. (That's smart!) If you're working on your computer when it's time to backup, the Galaxy will remind you it's time to take a five-minute break. Or, you can tell Galaxy to backup automatically after hours.

And, while the Galaxy backs up your data, it will display an on-screen status report.

NETWORK UPGRADEABLE

Add Genoa's GenWare™ software to your Galaxy tape backup system, and you can backup the data in your Novell network quickly and automatically. You can also easily exchange data between your stand-alone Galaxy units and your network units.

5 MB a minute! Genoa's menu-driven software makes it easy!

Genoa has the answer to the backup question: a whole family of tape backup units, from 20 to 120 MB, that are easy, automatic, and fast.

For the dealer nearest you or for more information, call 408-432-9090. Or write Genoa Systems Corporation, 73 E. Trimble Road, San Jose, CA 95131. FAX:408-434-0997, TELEX: 172319

Genoa

We make PCs better.

Circle 119 on Reader Service Card

Read Mac Disks on Your PC

A half-length add-in board, Matchmaker lets you hook up an external Macintosh drive to your IBM PC, XT, AT, or compatible. The board, along with its associated software, lets you easily move data between MS-DOS/PC-DOS and Macintosh disks using familiar DOS-style commands.

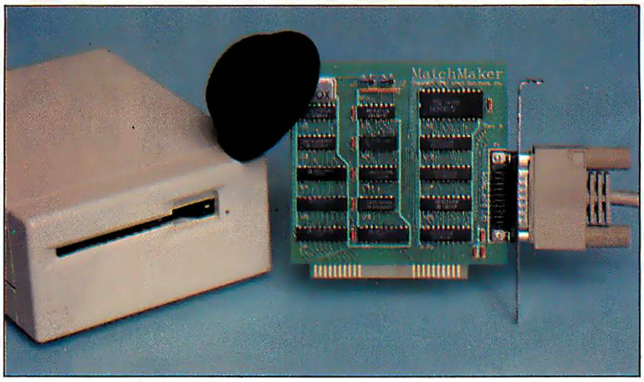
Software included with Matchmaker senses the type of Mac disk you're using. It supports both single-side (400K) and double-side (800K), as well as Macintosh folders on HFS (hierarchical file system) disks.

With Matchmaker, you can copy files to and from a Mac disk, view the contents of a Macintosh text file, initialize a Mac disk, and erase files. Matchmaker's software requires 192K bytes of RAM in your PC, and any version 2.x or 3.x of DOS.

Price: $149.

Contact: MicroSolutions Computer Products, 132 West Lincoln Highway, DeKalb, IL 60115. (815) 756-3411.

Inquiry 763.



Matchmakers hooks a Mac drive to your PC or compatible.

Multitasking Cross-Tabulation Spreadsheet

The data-analysis program A-Cross lets you cross-tabulate information in spreadsheet form while simultaneously creating, computing, and printing tables.

The program offers a variety of formatting, percentaging, and statistical options. You can create arrays of up to 26 rows by 100 columns, draw tables directly on the screen, and input from ASCII or IBM column binary files.

A-Cross requires no knowledge of a command language, and its formulas are translated into English onscreen.

A-Cross requires an IBM PC AT, XT, or compatible with at least 512K bytes of RAM, one floppy disk drive, a hard disk drive, PC-DOS or MS-DOS 2.15 or higher, and a monochrome, color, or EGA monitor.

Price: $995; run-time version, $85.

Contact: Strawberry Software, 42 Pleasant St., Watertown, MA 02172, (617) 923-8800.

Inquiry 764.

Handwritten Mac Input

Feel constrained by keyboard-and-mouse input on your Macintosh? According to Anatex, you can use their Personal Writer 15 to input data into your Mac by simply writing on a sheet of paper. Your written words appear typewritten on the screen.

The PW-15 package consists of a digitizer, an electronic pen, and character-recognition software that the company says is totally compatible with and transparent to all software running on the Macintosh. There's also a built-in 100,000-word dictionary for correcting spelling mistakes.

Personal Writer's character-recognition software learns the characteristics of your handwriting when you first use the device—writing unconnected letters. You can teach it variations in your writing style as they occur and at any time review the system's memory to add or delete letter shapes.

To use Personal Writer, you'll need a Macintosh Plus, SE, or II, For large applications, 2 megabytes of RAM are required. A hard disk is recommended. The PW-15 digitizer pad is available in two versions.

Price: $895 and $1395.

Contact: Anatex Inc., 1801 Avenue of the Stars, Suite 507, Los Angeles, CA 90067, (213) 556-1628.

Inquiry 765.

LISP Development on the Mac

MacScheme+Toolsmith is a LISP development environment for the Macintosh. It features an incremental native-code compiler and interpreter; high-level objects for menus, windows, and text editors; a toolbox of data structures and traps; and a source-code debugger. The lexically scoped language conforms to the 1986 Scheme language standard.

A new feature added to MacScheme is the application builder, which enables you to create stand-alone applications. A smart starter keeps the size of applications down. And Semantic Microsystems charges no royalty fees for applications you develop and distribute.

MacScheme+Toolsmith runs on any Macintosh or Mac II with at least 1 megabyte of RAM.

Price: $395.

Contact: Semantic Microsystems Inc. 4470 Southwest Hall, Suite 340, Beaverton, OR 97005, (503) 643-4539.

Inquiry 766.

Upgrade Your EGA

Photon MAXER is a graphics-enhancement system for any EGA add-in card that's faithful to the standard IBM EGA specification. The board plugs into the EGA's feature connector, and adds package-specific resolutions of 800 by 512, 720 by 540, or 640 by 480 pixels.

All of MAXER's enhanced EGA resolutions feature a 4-to-3 aspect ratio. This produces a square pixel for distortion-free graphics images. MAXER comes with software drivers for popular applications programs.

Price: $159.

Contact: Personal Computer Graphics Corp., 5819 Uplander Way, Culver City, CA 90230, (213) 216-0055.

Inquiry 767.

Low-Cost Large Mac Monitor

PROAPP has introduced a low-cost large-screen Macintosh monitor designed to work with either the Macintosh Plus or SE. The EyeSaver monitor measures 14 inches diagonally, for a viewing area twice the size of a normal 9-inch diagonal Macintosh screen.

The EyeSaver has paper-white phosphors and resolution equal to that of the 9-inch Mac screen. It comes with all cables required for hookup, and includes a 1-year warranty.

Price: $395.

Contact: PROAPP Inc., 10005 Muirlands, Suite M, Irvine, CA 92718, (714) 855-9088,

Inquiry 768.

continued

Amdek gives you the big picture. Or the bigger picture.

Since no two spreadsheets are alike, Amdek® is the one company that offers you a clear-cut monitor choice.

For example, look at the 410. Many consider it to be the workhorse of the industry. Its flat surface, 12" non-glare screen displays crisp, clean type that doesn't distort as it extends to the far corners of the screen. And, depending on the software, the 410 delivers up to 132 columns x 44 lines of text, giving you increased spreadsheet capability.

There's even an optional tilt/swivel stand that lets you select the most comfortable viewing angle.

More spread for your bread.

If your type of work requires even greater demands, Amdek's answer is the 1280.

The 15" white phosphor CRT really gives you the big picture. Because, now you can run Lotus 1-2-3® and Symphony® with expanded resolution.

The Amdek 1280 graphics subsystem displays up to four times more spreadsheet than a conventional monitor. That's 160 characters per line x 50 lines of data. Result: less scrolling, more efficiency.

It's black & white and read all over.

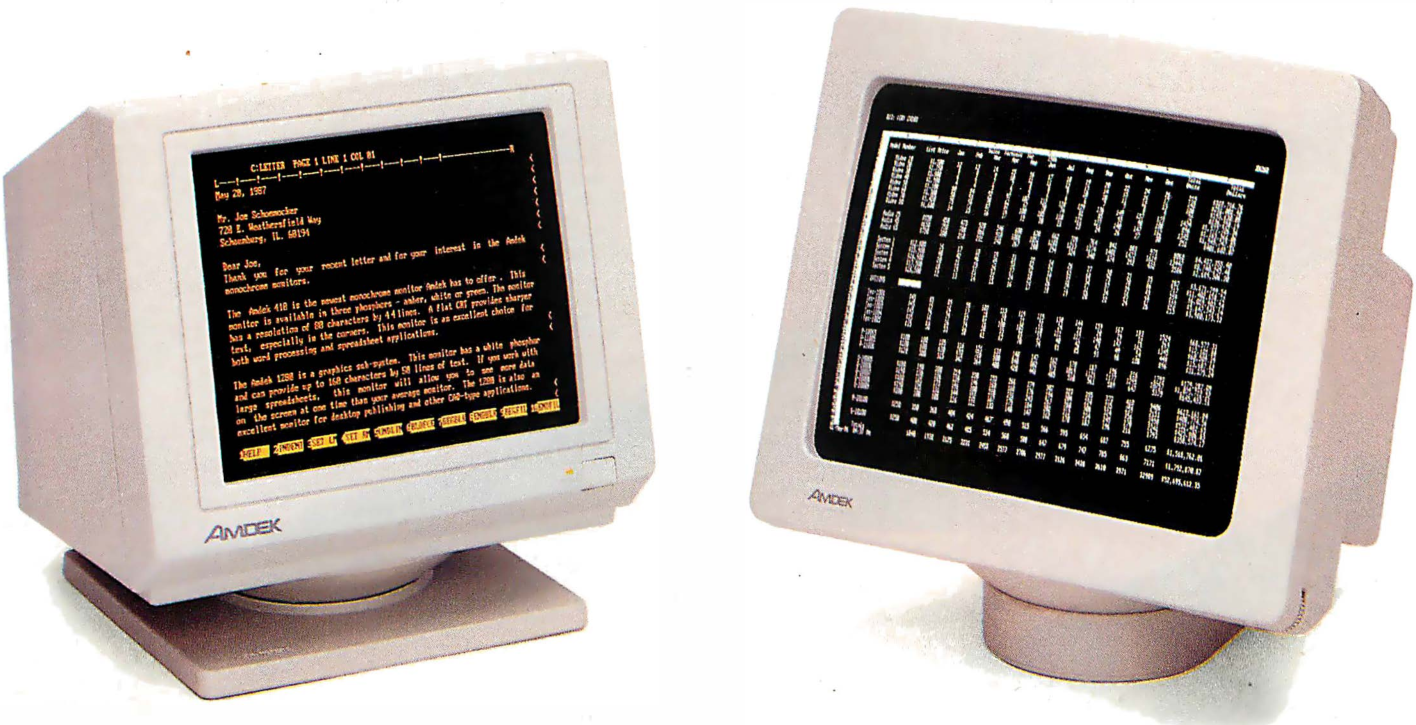
The 1280 will even provide you with complete color graphics compatibility displayed in shades of grey. So you can use high resolution when needed, and run all your existing CGA software on the same monitor. And thanks to a higher horizontal scan frequency, and the use of a 16 x 32 dot character cell (vs. 8 x 8 IBM® Standard), the 1280 offers much sharper type.

So if your work involves spreadsheets or word processing, Amdek understands your point of view.

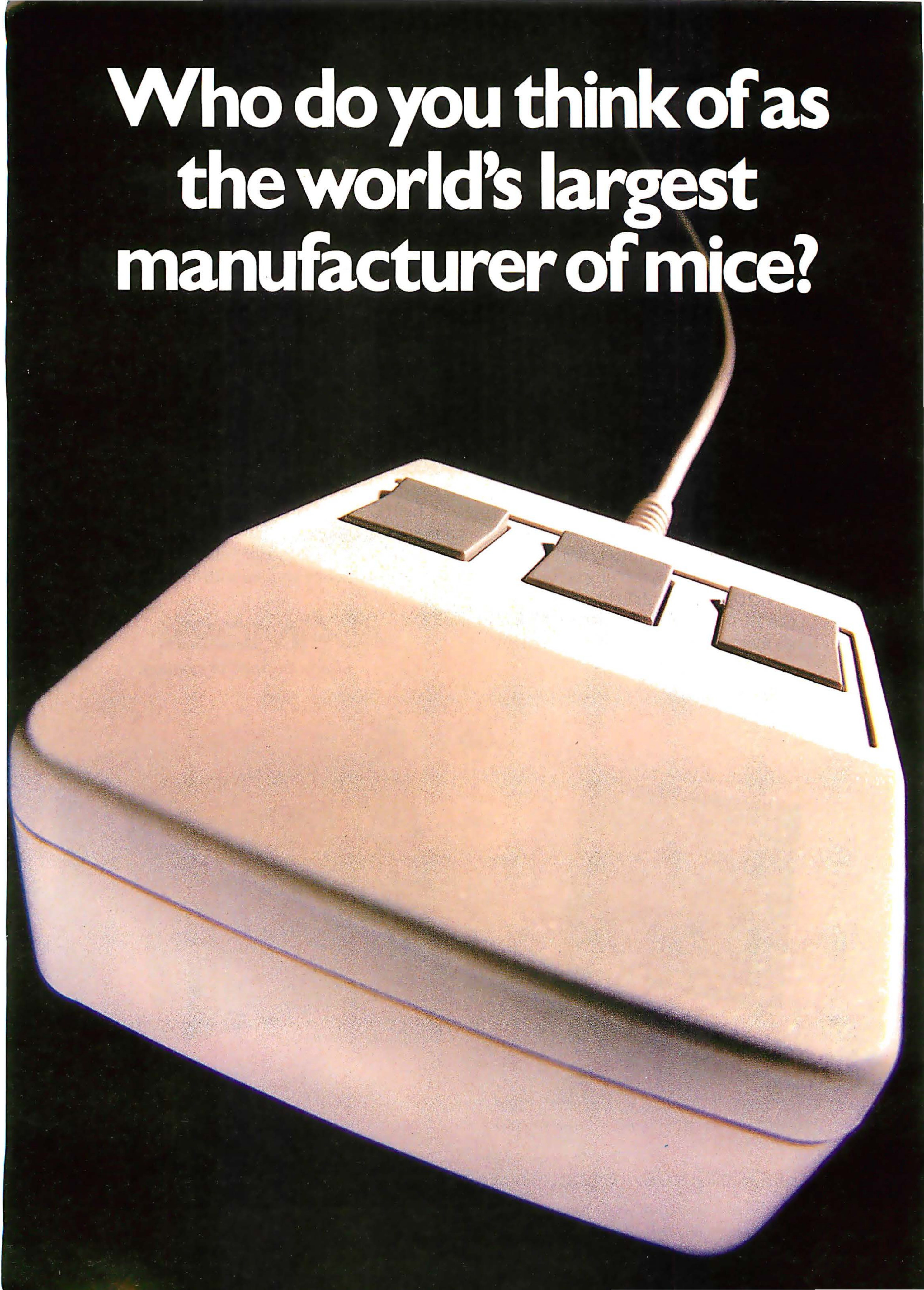
Call 800-PC-AMDEK to find out where you can see a demonstration of the 410 and 1280. Once you see what they can do for you, we don't think you'll want to picture yourself with anything else.

AMDEK

Clearly the finest in monitors.



1901 Zanker Road, San Jose, CA 95112 Phone: 800/PC-AMDEK (800/722-6335) FAX: 408/436-8187


Who do you think of as the world's largest manufacturer of mice?

Wrong.

It's not the name on the tip of your tongue.

But it's the name that soon will be: Logitech.

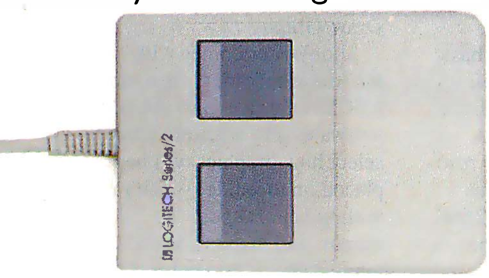
In our short history, we've manufactured over 750,000 mice. More than any other company in the world.

And we've supplied more mouse hardware, software and firmware to more major OEM's than anyone else.

And along the way, we've earned a reputation for our technological know-how in all facets of mouse production. That's because we design and manufacture our mice ourselves. We even publish our own software.

The result: A better, less expensive mouse. Which, when combined with our very affordable software, provides a complete solution for almost any graphics need.

But our achievements of the past are only a stepping stone for the future. Which is why we've designed the new LOGITECH Series 2 Mouse. It's 100% compatible with the latest IBM Personal System 2.™ And it plugs right into the mouse port, freeing the serial port for laser printers and other peripherals.



LOGITECH SERIES 2 MOUSE with Plus Software $99
Our new mouse is 100% compatible with IBM. Plus Software includes driver, programmable pop-up menu system, Point and Click Shell for 1-2-3,™ and Point, the mouse-based text editor.

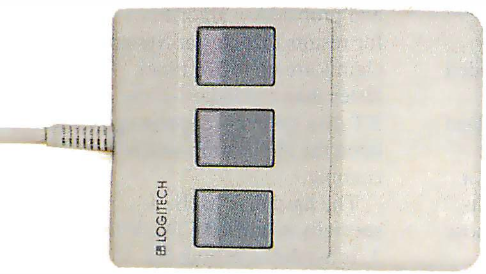
The LOGITECH Series 2 Mouse also offers superior hardware, and an ergonomic 2-button design which feels great to the hand. Plus it incorporates opto-mechanical technology, providing long-term reliability and excellent resolution.

And like all Logitech products, the new LOGITECH Series 2 Mouse is an excellent value for the dollar. Especially since it comes with our Plus Software, which makes our mouse even easier to use.

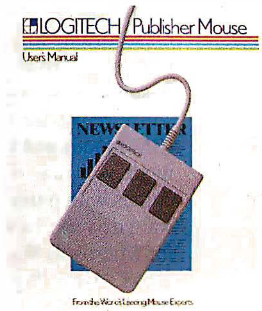
If you want more information about our products or the name of the dealer nearest you, call 800-231-7717 (800-552-8885 in California) or write: Logitech, Inc., 6505 Kaiser Drive, Fremont, CA 94555. In Europe, call 41-21-869-9656.

Now, once again, who do you think of as the world's largest manufacturer of mice? Right!

LOGITECH



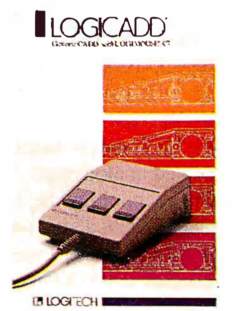
LOGITECH MOUSE with Plus Software $119
Consistently the reviewers' favorites, our Bus and Serial mouse products come complete with our Plus Software, which includes driver, Logimenu programmable pop-up menu system, Point and Click Shell for Lotus 1-2-3,™ and Point, the mouse-based text editor.



LOGITECH'S COMPLETE PUBLISHING SOLUTION $179
Mouse, Plus Software and PUBLISHER software. Produces high-impact, professional looking documents. Design templates make page layout easy. For beginner and advanced.



LOGITECH'S COMPLETE PAINT SOLUTION $149
With Mouse, Plus Software and LOGIPAINT. Creates files that move easily into both LOGICADD and Publisher documents.



LOGITECH'S COMPLETE CADD SOLUTION $189
For beginner to advanced, it's a complete solution for dimensioned line drawing and CADD. Package includes Mouse, Plus Software, and LOGICADD.

Circle 159 on Reader Service Card (Dealers: 160)

Convert Mac Images to DEC Formats

Reggie, from White Pine Software, converts MacDraw, MacPaint, and Clipboard images to DEC's ReGIS or SIXEL formats. You can use Reggie to import Mac graphics to DEC applications and output them on DEC terminals or output devices. You can also use Reggie to add color to Mac graphics and display the graphics on DEC terminals.

Reggie runs on Macs with at least 512K bytes of RAM. It also supports color on the Macintosh II.
Price: $99.
Contact: White Pine Software Inc., 94 Route 101A, P.O. Box 1108, Amherst, NH 03031, (603) 886-9050.
Inquiry 769.

Sensitive to the Touch

Tac & Touch is a glass touch screen for the Macintosh with a mouse-compatible software driver that allows all Macintosh software to work with the screen without modification. Versions are available for the Mac Plus, SE, and II.

MicroTouch Systems, the developers of Mac & Touch, say that this input device is significantly easier to use than the mouse because it is intuitive and easier to learn. Using it is simply a matter of touching the screen. The company also says Mac & Touch is more reliable because it has no moving parts or mechanical mechanisms to wear out. It takes no desk space, and is particularly well-suited to rugged or hostile environments.

Mac & Touch is based on a patented analog-capacitive sensing technology and is fabricated from a single glass sheet with a resistive coating bonded to its surface. The screen's controller measures the position of the capacitive coupling when a finger or conductive stylus touches the surface.

The screen has a resolution of 1024 by 1024 touch points. The controller can average the total area of finger contact to a single data point.
Price: Starting at $995.
Contact: MicroTouch Systems Inc. 10 State St., Woburn, MA 01801, (617) 935-0080.
Inquiry 770.

Toshiba's 6.4-pound Laptop

The Toshiba T1000 is the company's newest, smallest, lightest, and least-expensive laptop. Not exactly tipping the scales at 6.4 pounds, the T1000 is based on an 80C88 processor, and is not restricted by import regulations in effect at the time of this writing.

The T1000 measures 12.2 by 2.05 by 11 inches, has a built-in handle, and operates for up to 5 hours on its built-in rechargeable battery. Optional AC and automobile power adapters are also available.

The unit has a single 720K-byte 3½-inch floppy disk drive and 512K bytes of RAM. An optional memory card adds 128K bytes of user RAM and 640K of Lotus/Intel/Microsoft/Expanded Memory Specification (LIM/EMS) memory.

Software includes MS-DOS 2.11 in ROM. The T1000 boots automatically from ROM, leaving the entire disk space free for applications programs and data. An 80-column by 25-line supertwist LCD is standard, with 640 by 200 resolution and CGA compatibility.

Standard ports include a parallel printer, RS-232C serial, RGB video, composite video, external numeric keypad, and external drive. It has a clock/calendar and there's also space for Toshiba's optional 300-/1200-bps internal modem.

Other system options include an external numeric/cursor control keypad ($99), a 5¼-inch floppy disk drive ($499), MS-DOS 3.2 on disk ($75), and Floppy Link ($199), which connects the T1000's internal drive to an external PC drive for easy data transfer.
Price: $1199.
Contact: Toshiba America Inc., Information Systems Division, 9740 Irvine Blvd., Irvine, CA 92718, (714) 380-3000.
Inquiry 771.

Add VGA-compatibility to Your AT

The new Paradise PC VGA Card provides basic VGA compatibility to your AT or compatible. In addition, it provides enhanced VGA features with 800-by-600 resolution and 16 simultaneous colors out of a palette of 256K. There's also a 132-column mode.

This half-size 16-bit card has VGA hardware and BIOS compatibility, a custom Paradise PVGA chip, and Brooktree's 80-MHz Palette chip. It's complete with 512K bytes of video RAM, and 32K bytes of ROM.

With a maximum resolution of 1024 by 768 pixels and four simultaneous colors, the PC VGA card is also EGA-, CGA-, MDA-, and Hercules-compatible. It drives the IBM 8514 and compatible analog monitors, as well as all multisync-type monitors.

According to Paradise, no special drivers are needed to support the board; all software written for standard IBM modes and Hercules mode will run. However, it comes with numerous software drivers, including those for Microsoft Windows, GEM, Aldus PageMaker, Ventura Publisher, Lotus 1-2-3, Framework II, Microsoft Word, and others.
Price: $599.
Contact: Paradise Systems Inc., 150 North Hill Rd., Suite 8, Brisbane, CA 94005, (415) 468-7300.
Inquiry 772.

A Digital Film Recorder for the Mac

If you use a Macintosh, the Matrix SlideWriter will let you produce full-color 35mm presentation slides with a maximum resolution of 4096 lines (equal to the resolution of 35mm film).

Producing up to 30 slides per hour, the SlideWriter is compatible with the PICT file format supported by MacDraw, MacPaint, and other software packages including PowerPoint and Cricket Draw/Graph.

SlideWriter comes with the image recorder, film back, a SCSI interface, and utility software. The software lets you select how graphics will be placed on the slide, specify a scaling factor, spool the output, and map black-and-white patterns into color images.
Price: $11,795.
Contact: Matrix Corporation, One Ramland Rd., Orangeburg, NY 10962, (914) 365-0190.
Inquiry 773.

High-Speed Hard Disk System

Co-Star is a hard disk/controller system for IBM PCs, XTs, and compatibles that uses intelligent buffering and proprietary algorithms for results that Nestar Systems claims are up to 3.6 times faster than a standard-issue XT disk system—depending upon the application you're running.

The hard disk itself, a specially modified CDC Wren 3, is available in both 80-megabyte (half height) and 150-megabyte (full-height)

continued

THE WORLD'S SMARTEST ANSWERING MACHINE

PERSONAL VOICE MAIL
"Hello. I'm not available right now. Please wait for the tone and leave a detailed message. Touch the star to listen to what you've recorded."

PERSONAL MESSAGES FOR FREQUENT CALLERS
"Hello, I'm not ... # ... Dad! I'm not here, but my computer knows exactly where I am and will pass your message on to me immediately. Wait for the tone and tell me where you are. I'll call you right back."

REALLY PERSONAL MESSAGES FOR FREQUENT CALLERS
"Hello, I'm not avai ... # ... Anne! Sweetheart! I'm in the car, picking up your flowers. My car phone number is 993-1234 if you need me. Otherwise, see you at seven. Kiss-kiss-kiss!"

MESSAGE FORWARDING
"Hello. This is your answering machine calling... # ... Three new messages. Message one was received at 3:52PM today."



MULTIPLE VOICE MAIL BOXES
"Hi. This is the operating systems group. We're out to lunch, but you can leave a private message by dialing 11 for Diane, 12 for June, 13 for Joel and 14 for Bob. Or you can wait for the tone to leave a message for our secretary."

INCREASED SECRETARIAL PRODUCTIVITY
"This is Gene's voice mailbox. Please wait for the tone and leave a message. My computer knows where I am at all times and will call me immediately with your message. If you need to speak to someone right away, touch zero to transfer to my secretary."

DON'T FORGET MOM!
"This is Chip. Please ... # ... Hi, Mom. I've been waiting for your call. How's Europe? Thanks for remembering my birthday. Sorry I missed you, but I had to run some errands. See you Thursday at the airport."

OUTGOING MESSAGES
"This is Joel's computer calling. Just a reminder for Lynne and Rick — We have a budget review tomorrow morning at 8:00 o'clock. See you there."

Answering machines are irritating because they are so dumb. Even the best of them. For only $349, we'll give you personal voice mail for your PC, and turn it into the world's smartest answering machine. All without disturbing whatever else you've been doing on the PC.

How smart is "smartest?" The examples above . . . uh . . . speak for themselves. Sure, your PC can answer the phone in your voice, and let you retrieve messages remotely from any touch-tone phone. And it can call you to deliver your messages.

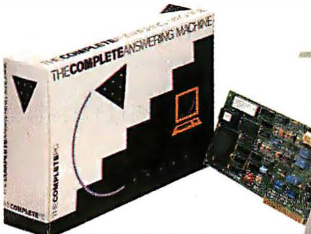
But give your friends and associates their own voice mailboxes. The ability to interrupt your greeting and start recording immediately. To deliver messages to each other as well as to you. The ability to transfer to other extensions. Even let them change their minds *and* their messages. Give them all this and you'll never again have to apologize for making people talk to a machine.

In your business, it will relieve your secretary of the burden of taking routine messages. And relieve you of the burden of transposed telephone numbers. In business or in personal use, it works 24 hours a day. Without irritating your callers like mere answering machines do. All while you're running your spreadsheet, word processor or just about anything else.

We call the world's smartest answering machine "CAM." For *Complete Answering Machine*. We call ourselves The Complete PC. And CAM is just the beginning of a whole line of smart products designed to help you get *more from your personal computer*.

You should call (800) 634-5558 today for the name of the CAM dealer* nearest you.

So tomorrow, you can give your old answering machine to someone who doesn't mind annoying people.



THE COMPLETE PC

More from your personal computer

521 Cottonwood Drive • Milpitas, California 95035
408 434-0145 • 800 634-5558 • FAX 408 434-1048

Circle 61 on Reader Service Card

*CAM is available now from:
R + R Direct (1-800-654-7587) • Radio Shack (Cat. No. 90-2137) • MicroAge Computer Stores

versions. The SCSI interface card requires a full-length slot and has its own on-board 8-MHz NEC V40 processor for disk control.

The company says the board treats the disk like a LAN fileserver, and performs sophisticated disk and file management that orders the data so that minimum head movement is needed for retrieval. The interface board includes both serial and parallel ports and can use its on-board 256K bytes of RAM for print spooling.

Price: 80 megabytes, $1495; 150 megabytes, $2495.

Contact: Nestar Systems, 1345 Shorebird Way, Mountain View, CA 94043, (415) 969-1777.

Inquiry 774.

Macintosh Document Processor

Ragtime 2, a document processor designed for the Macintosh Plus, SE, and II, combines page-layout capabilities with word-processing, spreadsheet, and graphics-management features. Page-layout features include overlapping frames, kerning, and snap-to grids. The word processor includes automatic hyphenation and spell checking. The spreadsheet offers mail-merge and sort functions. The spreadsheet can also utilize the Macintosh II 68881 math coprocessor.

Ragtime 2 lets you import text files from MacWrite and Microsoft Word, data files from SYLK, and graphics files from MacPaint, PICT, EPS, and TIFF.

The program is not copy protected and runs on the Mac 512K Enhanced, the Mac Plus, SE, or II with color. You need a minimum of 800K bytes of RAM or a hard disk drive. It supports the Imagewriter, LaserWriter, and other PostScript output devices.

Price: $395.

Contact: Orange Micro Inc., 1400 North Lakeview Ave., Anaheim, CA 92807, (714) 779-2772.

Inquiry 775.

Printer Buffer Shares Data

Lil'Devil printer sharing/buffer is a print buffer with a difference from competing models. The Lil'Devil's 16K-byte buffer is on a removable cartridge. In an environment such as an office with many PCs and few printers (or vice-versa), documents can be "printed" to the RAM cartridge, which you can then carry to a printer equipped with another Lil'Devil for printout.

Equipped with a standard parallel-printer jack and a printer cable with a standard Centronics-style parallel plug, you can easily connect the Lil'Devil between your computer and printer. But because of its standard RAM cartridge features, you can also connect the unit to your computer sans printer; or to your printer sans computer. Extra 16K-byte RAM cartridges are also available.

Price: $149.95; extra catridges, $35.

Contact: PAMCO Electronics, Rubin Business Center, 920 Blairhill Rd., Suite 101, Charlotte, NC 28210, (704) 529-1593.

Inquiry 776.

Shared Modem for AppleTalk

Designed to be shared by Macintosh computers operating over the AppleTalk network, Shiva's NetModem V1200 is a 1200-bps modem with full Hayes compatibility. According to the company, the NetModem is the first modem designed expressly for the Macintosh, with a combination of Hayes-like commands, on-line help, on-line status indicators, and audible call monitoring through your Mac's built-in speaker.

The NetModem V1200 uses an internal 8051 processor operating at 11.06 MHz, and interfaces with AppleTalk via an 8530 serial communications controller. The unit has 2K bytes of RAM, 16K bytes of ROM, and 32 bytes of nonvolatile storage.

Weighing 3 pounds, the NetModem V1200 measures 1.5 by 5.5 by 9.5 inches, and is compatible with all Macintosh communications software. To use it, you'll need an AppleTalk network, a Mac 512, Plus, SE, or II, and System 4.1/Finder 5.5.

Price: $599.

Contact: Shiva Corp., 222 Third St., Suite 1200, Cambridge, MA 02142, (617) 661-2026.

Inquiry 777.

A Flash-Up Macro Utility

Flash-Up is a memory-resident program that enables you to create macros, design custom menus, and attach notes to text documents, databases, and spreadsheets.

Flash-Up Developer's ToolBox is a separate program that includes a programming-language interface and enables you to control and display macros, menus, and notes from most programming languages. It includes a run-time module and requires Flash-Up to run.

Flash-Up includes an on-line window editor and supports mice. Both programs run on IBM PCs and compatibles with MS-DOS or PC-DOS 2.0 or higher. Flash-Up takes up 128K bytes of RAM, and the Developer's ToolBox uses 60K bytes.

Price: Flash-Up, $89; Flash-Up Developer's ToolBox, $49.

Contact: The Software Bottling Company, 6600 Long Island Expressway, Maspeth, NY 11378, (718) 458-3700.

Inquiry 778.

Behind-Bezel Filter

According to Sun-Flex, standard optically coated and polarized antiglare filters for CRTs are inherently reflective, producing additional visible reflections. That's why the company's line of behind-the-bezel Voltfree conductive filters hug the contours of the tube and use a microfiber system that works like slats in venetian blinds, blocking reflections that come in at an angle—both up and down and side to side.

In addition, the filters block diffuse glare with a shadow-box effect; the screen reflects the back of the filter instead of the wall or another surface behind you. Sun-Flex Voltfree filters are also electrically conductive and connect to ground. The company says the filters resist fingerprints, require cleaning infrequently, and don't require special cleaning fluids when they do need maintenance.

Price: $50 to $80, depending upon monitor.

Contact: Sun-Flex Company Inc., 20 Pimentel Court, Novato, CA 94947-5667, (800) 321-1659; in California, (415) 883-1221.

Inquiry 779.

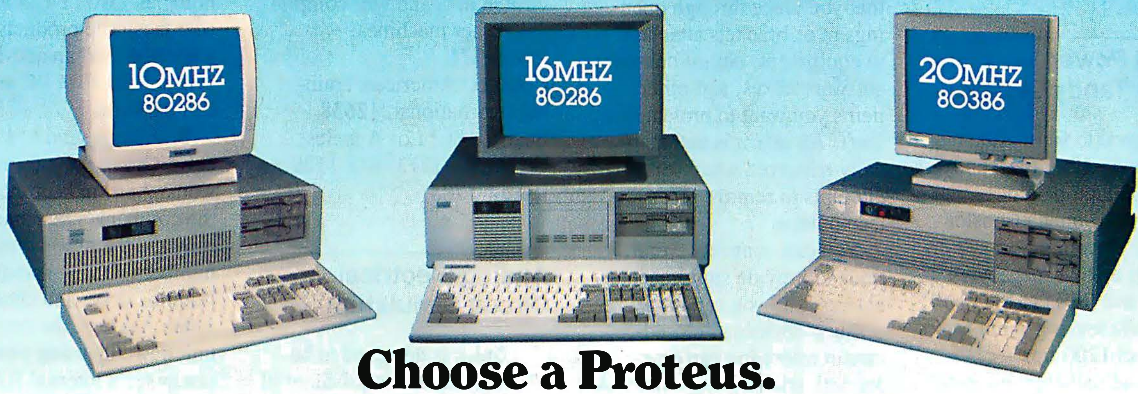
Full-Page PC Monitor

The Superview 1280 from Epsilon Graphics Corporation is a 19-inch full-page monochrome display system designed for desktop publishing and CAD applications on IBM PCs, XTs, ATs, and compatibles. The unit has a resolution of 1280 by 960 pixels.

The 1280 system includes the monitor, controller, cables, and installation utilities. CGA compatibility is standard for most popular applications software. The package includes custom drivers for GEM, Microsoft Windows, AutoCAD, Xerox Ventura Publisher, and Aldus PageMaker.

continued

How to get a top quality, U.S. made IBM compatible without spending a bundle...



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You may be able to solve them yourself with our unique 24-hour on-line interactive support system, which is always free of charge.

There are many reasons for owning a Proteus. The experts think so too.

In a recent AT compatible product comparison, *Infoworld* (4/87) stated *"...for overall best machine in power, the Proteus 286e is the clear winner. It offered the best CPU and hard disk random read/write performance of any machines tested, is remarkably easy to set up, and boasts the best support around. We recommend it."*
EDITOR'S CHOICE

"...There are so many nice aspects to Proteus and the company that makes it, there isn't room to cover them all."
Business Computer Digest (3/87)

PROTEUS SYSTEMS

MODELS	286E	286F	286GTX	386A	386i
INTEL CPU:	80286-10	80286-10	80286-12	80386	80386
CLOCK SPEED	8/10MHz	8/10MHz	6/12MHz	6/16MHz opt. 20MHz	8/16MHz 18
NORTONS.I.	10.1	11.5	15.3	23.5 opt. 31.6	18.7
BASE MEMORY	1024K	1024K	1024K	1024K to 4MB	512K
WAIT STATES	ONE	ZERO	ZERO	ZERO	ONE
KBD SELECT. SPEEDS	NO	YES	YES	YES	YES
CLOCK. CAL./BATTERY ONBD.	YES	YES	YES	YES	YES
COPROCESSOR SOCKET	80287	80287	80287	80287	80387
SERIAL PORTS	TWO	TWO	TWO	TWO	ONE
PARALLEL PORT	ONE	ONE	ONE	ONE	ONE
I/O SLOTS	EIGHT	EIGHT	EIGHT	EIGHT	EIGHT
HARD DISK-FD CONTROLLER	YES	YES	YES	YES	YES
FLOPPY DISKS	1.2MB	1.2MB	1.2MB	1.2MB	YES
HARD DISK	20MB	20MB	20MB	40MB	40MB
306K OR 3.5" FD CHOICE	YES	YES	YES	YES	YES
KEYBOARD TYPE	84-KEY	84-KEY	101-KEY	101-KEY	101-KEY
FREE CUSTOMER SITE SERVICE	YES	YES	YES	YES	YES
SYSTEM PRICE	$1569	$1774	$2674	$3195	$3195

HARD DISKS: Seagate, Miniscribe, Priam *starting* $279
MONITORS: High Res. Monochrome, Color, EGA *from* $109
ADD-ONS: EGA/CGA Mono Cards *from* $98
MEMORY EXPANSION: *from* $65
MODEMS: 300/1200/2400 *from* $119

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Hasbrouck Heights, N.J. 07604

proteus™
The Intelligent Conclusion

Price: $2395.
Contact: Epsilon Graphics Corp., 1370 East Edinger Ave., Santa Ana, CA 92705, (714) 558-1288.
Inquiry 780.

Adding Power to Your Tandy Laptop

Designed to fit on the base of either the Tandy 100 or 102 laptop computers, the 10-ounce Booster Pak from Traveling Software adds up to 2 megabytes of RAM and ROM to the units, while leaving room for an optional 1200-bps modem and rechargeable battery pack.

The basic Booster Pak includes 136K bytes of RAM, 96K bytes of which is available for file storage. There's also 64K bytes of built-in ROM software, including the TS-DOS operating system, a game, and a communication package with XMODEM capabilities. The unit has 11 open sockets for either RAM or ROM chips, and six slots for 256K RAM packs.

Traveling Software says the Booster Pak makes it easy to switch from one ROM-based program to another, and can hold multi-ROM programs of up to 480K. The unit's RAM requires no bank-switching, and you can access it directly from BASIC.

The Booster Pak adds ¾ inch to the bottom of the Tandy 100 or 102, and attaches with two simple clips (no screwdriver needed).
Price: $429; 32K RAM chips, $20; six-slot RAM expansion board, $69; 256K RAM expansion modules, $159; 1200-bps modem, $199.95; rechargeable battery pack $69.
Contact: Traveling Software Inc., 19310 North Creek Parkway, Bothell, WA 98011, (800) 343-8088, (206) 483-8088.
Inquiry 781.

Fiber-Based PC Security

Microsafe's security systems feature a light-supervised fiber-optic cable that you place through openings in or brackets attached to equipment, circuit boards, software boxes, and other items you want to protect from theft. An alarm is automatically triggered when someone attempts to remove protected items.

You can connect several units to provide simultaneous alarms, and you can hook up such devices as closed-circuit television cameras for activation by the system. A keyswitch activates security modes, and you can select how sensitive the system will be and its alarm-sounding options.

Both wall-mounted and line-cord models are available. Optional equipment includes power outlets with commercial-grade voltage surge and spike protection, a resettable circuit breaker, and multimode EMI/RFI (electromagnetic interference/radio frequency interference) filtering for connected equipment. The standard cable with each system is 12 feet long, and replacement cables of up to 100 feet are available.
Price: Starting at $201.50.
Contact: Microsafe Products Co., P.O. Box 2393, Kirkland, WA 98083-2393, (206) 881-6390.
Inquiry 782.

A Paradox Tutorial

Teach Yourself Paradox is a two-disk training package designed to teach you how to use Paradox, Ansa's database program. Split-screen graphics provide you with a simulation of Paradox screens as well as step-by-step instructions. Forward and backward paging, place marking, menu access, branching, activity reviews, content summaries, and skill-building exercises facilitate self-directed learning.

Teach Yourself Paradox runs on IBM PCs, XTs, ATs, and compatibles with 128K bytes of RAM, one double-sided floppy disk drive, and MS-DOS or PC-DOS 1.1 or higher. The program is written in C and will compile onto other machines.
Price: $75.
Contact: American Training International, 12638 Beatrice St., Los Angeles, CA 90066, (213) 823-1129.
Inquiry 783.

Analog Electrical Circuit Simulation

PSpice is designed to be the software equivalent of a breadboard. Incorporating a superset of Harris's Spice II program, PSpice calculates voltages and currents for ICs as well as printed circuit boards. Options include a digital-files interface to Viewsim, Silos, and PLogic digital simulators, which lets you read the results from a digital simulation into PSpice. Another option is a graphical waveform viewer that is designed to be the software equivalent of an oscilloscope. The graphics option supports EGA-, CGA-, and Hercules-compatible graphics.

PSpice runs on IBM PCs, XTs, ATs, and compatibles with 640K bytes of RAM, a math coprocessor, and PC-DOS or MS-DOS 3.0 or higher. A hard disk drive is recommended. The program also runs on MicroVAX machines under VMS and Sun 3 UNIX machines.
Price: IBM PC version, $950; MicroVAX and Sun versions, $1900; digital-files option, $350 and $700, respectively; graphical waveform option, $450 and $900, respectively.
Contact: MicroSim Corp., 23175 La Cadena Dr., Laguna Hills, CA 92653, (800) 826-8603; in CA, (714) 770-3022.
Inquiry 784.

Just the Fax

With apologies to Sergeant Joe Friday, the name "JT Fax" is short for "just the Fax." Asher Technologies' two JT Fax low-cost facsimile products include a portable and an add-in card for the IBM PC and compatibles.

Both units send and receive Group 3 fax transmissions. And, in keeping with the company's penchant for acronyms, the unit's model number—DSC—stands for "dumb, slow, and cheap." Asher has kept the cost of the unit down by using your computer's internal RAM instead of having its own.

JT Fax comes with a memory-resident program that controls both transmission and reception of fax. Fax reception cannot take place in the background. Instead, JT Fax's software puts a message on the screen, and freezes the display until the incoming fax is received (approximately two minutes per page).

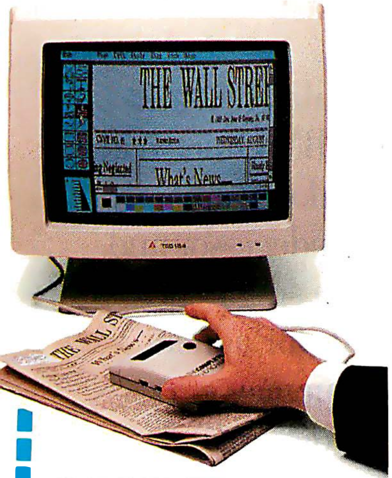
For transmission, JT Fax can accept either ASCII data or input from an external scanner input. You can schedule the unit to send a fax to one person or a group, either right away or at a preselected time in the future. The software keeps a transaction log of both incoming and outgoing messages. The software also lets you attach a digitized letterhead and signature to your fax documents.

The JT Fax internal card requires a half-length slot in any IBM PC or compatible. The external portable unit measures 3½ by 6 by 1 inches, and hooks up to your system's RS-232C serial port.
Price: $395; portable model, $495.
Contact: Asher Technologies Inc., 1009-I Mansell Rd., Roswell, GA 30076, (800) 334-9339, (404) 993-4590.
Inquiry 785.

continued

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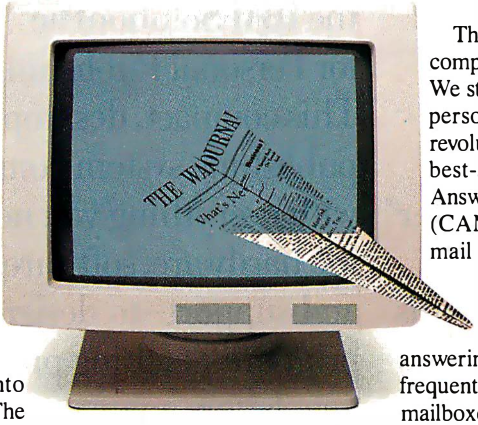
Scan a 2½ inch wide image at a resolution of 200 dots per inch. Merge it. Crop it. Rotate it. Insert it. Scale it. Color it. Then print it with your dot-matrix or laser printer. You can even . . .

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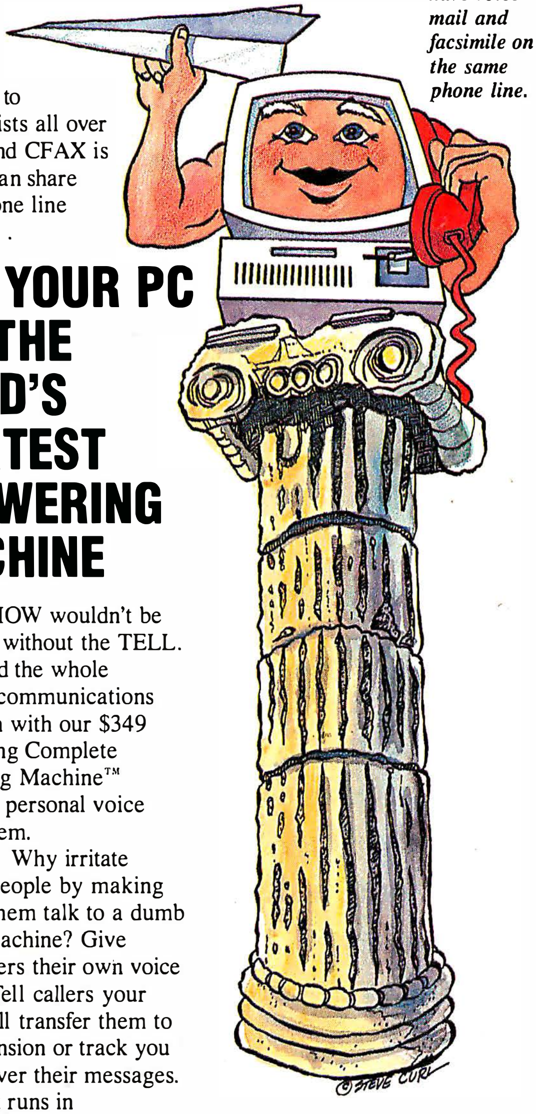
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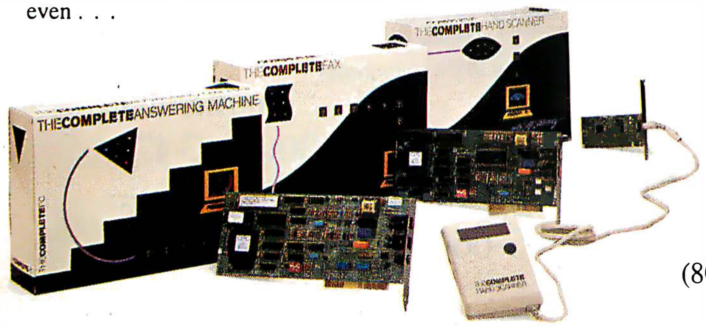
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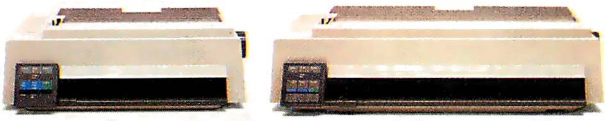
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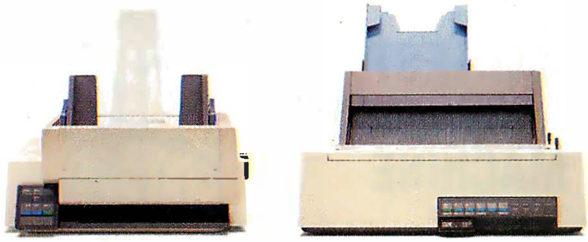
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SYSTEMS

New GRiD Handles Add-In Cards

GRiD's latest laptop computer is the GRiDCase EXP (for expandable). This system's claim to fame is that it has room for two full-length XT-type (8-bit) expansion cards. The unit runs off AC power, although you can get an internal rechargeable battery pack.

Weighing 15 pounds, and measuring 15 by 11.5 by 3.5 inches, the EXP has a magnesium case, and is based on a CMOS 8086 4.77-MHz processor. There's also a socket for an 8087 coprocessor.

The EXP's standard hardware features include 640K bytes of RAM, a single 720K-byte 3½-inch floppy disk drive, single serial and parallel ports, an RGB output port, and a supertwist LCD display. Options include a 20-megabyte internal hard disk drive, 1 megabyte of EMS RAM, an internal 300-/1200-/2400-bps modem, and a gas plasma display.
Price: $4640; hard disk, $1175; modem, $595; plasma display, $530; 1 megabyte EMS RAM, $395.
Contact: GRiD Systems Corp., 47211 Lakeview Blvd., Fremont, CA 94538, (415) 656-4700.
Inquiry 786.



The GRiDCase EXP takes two full-length expansion cards.

Amiga-Based Video Editing System

The MediaPhile 8mm video editing system includes a Sony EVS700 video cassette deck, a CCD (charge-coupled device) V110 camcorder, an Amiga computer, and an interface unit to tie the whole thing together. Using the Amiga mouse and an on-screen menu, you can choose and perform all video deck functions.

You can perform assembly edits and insert edits from the deck to the camcorder using an edit list of up to 1000 entries. Video editing features include audio dubbing in stereo, flying erase heads, and preroll. You can also overlay Amiga graphic images onto live video, having them recorded automatically from the edit list. Additional VHS, Beta, and 3/4-inch decks can also be hooked up to the MediaPhile system.

If you already have an Amiga, a VCR, and/or a camera, you can purchase the MediaPhile System as discrete components. A demonstration tape is also available.
Price: Complete system, $4026; system less Amiga, $2548; interface unit and software, $513; demonstration tape, $25.
Contact: Interactive MicroSystems, P.O. Box 272, Boxford, MA 01921, (617) 887-9607.
Inquiry 787.

NCR's Modular AT

The PC710 from NCR is a 10-MHz 80286-based system that you can configure to your personal requirements by adding discrete functional modules. The base system consists of a layer that contains the system's processor board, disk drives, power supply, and a personality card that combines the functions of the video adapter, disk drive controller, extended memory, and both serial and parallel ports.

Add-on layers snap onto the base system without the need for tools. Options include a layer that accepts two standard full-length AT cards; a layer for half-size cards and one or two 3½-inch floppy or hard disk drives; and a layer with a single 5¼-inch floppy disk drive and a tape-backup unit. You can set up your system with a maximum of eight available expansion slots and four disk drives.

The basic system includes 640K bytes of RAM, an 80287 math coprocessor socket, CGA or EGA video, a single 3½-inch floppy disk drive, and NCR DOS 3.2. Memory is expandable to 1 megabyte on the processor board, and up to 16 megabytes using expansion boards. The company says PC710 owners will eventually be able to upgrade to an 80386 processor.
Price: Basic system, $1954 with CGA, $2154 with EGA; dual-drive system, $2144 with CGA, $2344 with EGA; hard-disk system, $2670 with CGA, $2870 with EGA; expansion layers, $395 to $1390.
Contact: NCR Corp., 1700 South Patterson Blvd., Dayton, OH 45479, (513) 445-2380.
Inquiry 788.

A Complete CAD System

It's called Super CUB Plus, and it's a complete low-cost color CAD system that includes everything you need to do the job including a printer/plotter. The system consists of an IBM PC AT-compatible computer with an 80287 math coprocessor, a 20-megabyte hard disk, EGA display, a mouse, and Innovative Computer Aided Technology's CUB software.

The CUB software is a full two-dimensional design and drafting package designed for mechanical-design applications on PCs and compatibles. It includes double-work parametric mathematical calculations, automatic associative dimensioning, multiple pick and reject operations, automatic isometric-view generation, pan and zoom operations, and a standard library.

The printer/plotter included with the system is the JDL-850 EWS, which can plot with up to 14 colors. It can produce up to a C-size plot in both engineering and architectural formats, and performs normal printing in both draft- and letter-quality modes.
Price: $9995 complete; without printer/plotter, $6595; CUB software only, $2500.
Contact: Innovative Computer Aided Technology Inc., 14979 Prairie Ave., Suite 2, Lawndale, CA 90260, (213) 644-2949.
Inquiry 789.

continued



SAMSUNG
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SAMSUNG S-286 Base System $995

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S-286 Monochrome System $1135

- Base System • Monographics Card
- Samsung 12" Amber Monitor with Tilt & Swivel

With 20Mb Seagate St-225 .... $1405

With 30Mb Seagate ST-4038 F/H (39ms) $1625

S-286 EGA System $1510

- Base System • Video-7 VEGA DELUXE EGA Card
- Sansung or Goldstar 14" EGA Color Monitor

With 20Mb Seagate ST-225 .... $1780

With 30Mb Seagate ST-4038 F/H (39ms) $2000

Additonal 512K RAM with 100 Ns Chips ... $90

88 Turbo 10 MHz base System $549

- 8088-2 CPU 4.77/10 MHZ with 8 Expansion Slots
- 640K on board with ERFO BIOS • XT Keyboard
- Milti I/O with Floppy Disk Controller (Clock/ Game Port/1 Serial Port/1 Parallel Port)
- 1 Fujitsu Floppy Disk Drive • Monographic Board
- H/W Reference Manual

Complete Monochrome System $689

- Base System
- 1 additional 360K Floppy Disk Drive
- Samsung 12" Amber Monitor with Tilt & Swivel Base

88 Turbo 8 MHz Base System $530

Complete Monochrome System $670

OPTIONAL PRODUCTS

- Samsung 12" Amber or Green Monochrome Monitor with tilt & swivel base $75
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- NEC Multisync EGA monitor 549
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Circle 220 on Reader Service Card

PERIPHERALS

5¼-inch MS-DOS Drive for the Mac

DaynaFile is a floppy disk drive unit that hooks directly to the SCSI port on your Macintosh Plus, SE, or II. Using nothing but Macintosh applications, you can use DaynaFile to read from or write to MS-DOS-formatted disks.

DaynaFile is available in both single- and dual-drive configurations, in any combination of 360K-byte or 1.2-megabyte 5¼-inch disk drives; or 720K-byte or 1.44-megabyte 3½-inch disk drives.

According to its maker, DaynaFile fully supports Macintosh Finder applications, so your Mac manages the DaynaFile drives just as if they were Mac drives. DOS disks appear as disk icons that can be selected, dragged, and opened as if they were Macintosh disks. Subdirectories on the DOS disk also become Mac folders.

For even greater compatibility, the company offers Dayna data-file translation software that allows you to access certain MS-DOS files from the Mac without loosing formatting attributes.
Price: Starting at $595; translation software, $95.
Contact: Dayna Communications Inc., 50 South Main St., Salt Lake City, UT 84144, (801) 531-0600.
Inquiry 790.


Dayna File lets your Mac read and write MS-DOS disks.

Two New Laser Printers

CPT's LP-8GS is a desktop laser printer designed especially for technical applications. There are 24 resident portrait and landscape fonts that are standard on the unit, including four with scientific symbol support.

With 2.5 megabytes of RAM, the LP-8GS has enough memory for an 8½- by 14-inch full-resolution graphics page, with 852K bytes left over for optional downloadable fonts. Rated maximum print speed is eight pages per minute.

The printer emulates HP LaserJet Plus, Epson FX-80, Diablo, Qume, Tektronix, and ANSI printers. An optional dual-tray sheet and envelope feeder is available.
Price: $6000.
Contact: CPT Corp., 8100 Mitchell Rd., P.O. Box 295, Minneapolis, MN 55440, (612) 937-8000.
Inquiry 791.

On the lower-end of the laser printer scale, AST Research's TurboLaser/EL is a low-cost entry-level printer for those who don't need sophisticated features at the start. As your needs expand, you can purchase printer-upgrade kits to expand the printer's capabilities.

The TurboLaser/EL uses a Ricoh 4081 print engine with a maximum speed of eight pages per minute. Resolution is 300 dots per inch for text; 150 dpi for full-page graphics. The unit comes with AST's proprietary Laser Printer Controller, a PC expansion board that performs printer-control functions. The board uses a 68000 processor running at 12 MHz, and provides HP LaserJet and Diablo 630 emulation.

Five standard downloadable fonts come with the EL. Other standard features include 512K bytes of RAM and 250-sheet input and output trays. Three upgrade kits are available: The language upgrade option provides additional emulations, 1.5 megabytes of RAM, and more fonts; the EL memory upgrade adds 512K bytes of RAM to the printer; and the PostScript option adds 3 megabytes of RAM, 1 megabyte of ROM, and additional features.
Price: $1995; language upgrade, $995; memory upgrade, $395; PostScript option, $2495.
Contact: AST Research, 2121 Alton Ave., Irvine, CA 92714, (714) 863-1333.
Inquiry 792.

Macintosh Capture Machine

ProViz, by PixelLogic, is a second-generation video digitizer for any Macintosh with a SCSI interface and a megabyte of RAM. With ProViz, you can digitize images from flat copy as well as from any standard video source, including camera, videotape, television, or another computer.

Because ProViz can save files in encapsulated PostScript, the files are insertable into most desktop-publishing applications, where you can scale, stretch, and crop them. Other file formats supported include MacPaint, Thunderscan, and ProViz's own proprietary format. ProViz also allows you to edit files and store them on videotape.

ProViz comes in a cabinet that measures 3.5 by 10.25 by 11.5 inches and has brightness and contrast controls. It accepts any standard NTSC RS-170 composite video signal, digitizes a single frame in 1/30 second, and transfers the results to your Mac in less than a second.
Price: $1595.
Contact: PixelLogic Inc., 38 Montvale Ave., Stoneham, MA 02180, (617) 438-5520.
Inquiry 793.

40-meg Internal Drive for the SE

The PROAPP 40SEi is a 40-megabyte internal disk drive for the Macintosh SE. It can be installed without removing one of the SE's floppy disk drives.

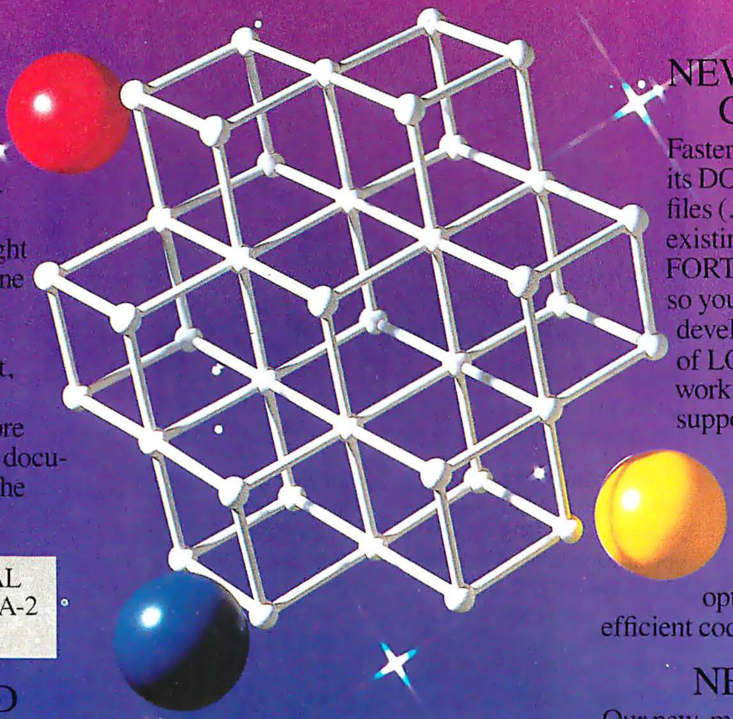
The drive incorporates a SCSI interface and is manufactured by Conner Peripherals. It uses voice-coil technology in place of the usual stepper motor. According to the company, voice-coil technology is faster and more reliable than steppers, because of fewer moving parts. Average access time of the drive is 29 milliseconds.

Power consumption of the 40SEi averages 6 watts, about half of what the Apple internal drive draws. The unit has automatic head lock and park on power-down, and PROAPP claims the drive can withstand up to 75 Gs while running without damage. A 100-megabyte version will be available by the end of the year.
Price: $1295.
Contact: PROAPP Inc., 10005 Muirlands, Suite O, Irvine, CA 92718, (714) 855-9088.
Inquiry 794.

continued

SOFTWARE ENGINEERING COMES OF AGE.

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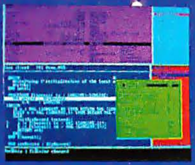


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Circle 161 on Reader Service Card (Dealers: 162)

ADD-INS

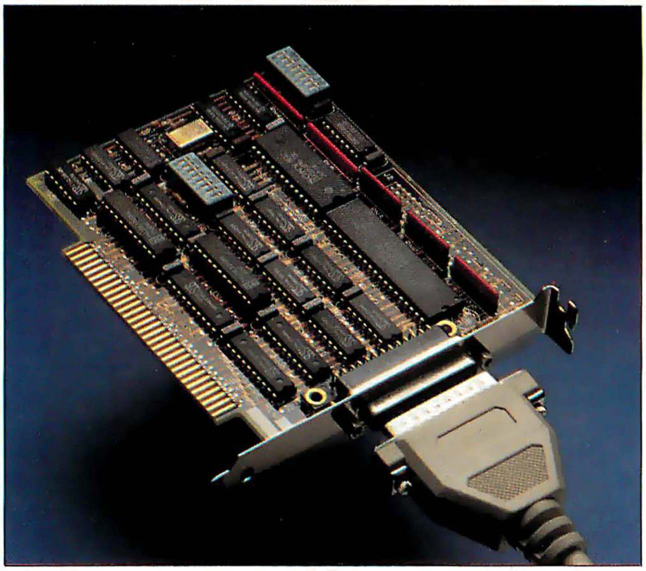
Connect Your Mac and PC

Although QuickShare from Compatible Systems is one of the many products available that allow a Macintosh and PC (or compatible) to share data, it has important differences: QuickShare allows you to establish a direct-connect high-speed data link between the machines, and even share your hard disk between the two machines.

QuickShare consists of a half-length SCSI add-in board for your PC or compatible, and a cable from the board that plugs directly into the SCSI port of a Macintosh Plus, SE, or II. Once connected, the Macintosh will boot directly from the PC storage device (hard disk or network), and access them as if they were the Mac's own.

QuickShare provides a simple method for transferring data from virtually any PC-based program to your Macintosh. And for PC programs that don't have the ability to export data files or graphics, it includes a pop-up software utility that redirects the printer output of any PC program into a data file that's accessible by the Macintosh.

No reformatting or repartitioning of your hard disk is required to install and operate Quickshare.
Price: $465.
Contact: Compatible Systems Corp., P.O. Drawer 17220, Boulder, CO 80308-7220, (303) 444-9532.
Inquiry 795.



QuickShare lets your Mac share your PC's hard disk.

HiCard Extends Conventional DOS Memory

HiCard is a short-slot 256K/512K RAM expansion card that expands the memory of your PC, XT, AT or compatible to a maximum of 896K bytes. The card extends standard DOS memory to 704K and adds up to 192K of high memory.

The board is MS-DOS compatible and fully supports Network-OS, CBIS's LAN operating system. When used with Network-OS, HiCard loads the network drivers and spoolers into high memory and frees standard DOS for other applications.
Price: $350.
Contact: CBIS Inc., 2323 Cheshire Bridge Rd., Atlanta, GA 30324, (404) 634-3079.
Inquiry 796.

Muscle AT Power Supply

Is a system unit that's chock full of add-in boards putting a strain on your AT's power supply? Most ATs and compatibles have a 225-W power supply, which isn't enough to power an 80386-based system and 8 megabytes of RAM, or a system fully loaded with high-drain boards.

You can solve the problem with NCR's new digital-switching power system, which is rated at 335 W and is interchangeable with any current AT power supply. It has a larger fan for additional cooling capacity and meets all current standards for electrical safety and interference.
Price: $265.
Contact: NCR Power Systems, 3200 Lake Emma Rd., Lake Mary, FL 32746, (800) 327-7612, (305) 323-9250.
Inquiry 797.

NEC Board Upgrades MultiSync

NEC has introduced a new add-in graphics card for ATs and compatibles. The MVA (MultiSync Video Adapter) 1024 supports the family of NEC MultiSync monitors by driving the original MultiSync at resolutions of up to 640 by 480. With the board, the MultiSync Plus can display 960 by 720; the Multisync XL up to 1024 by 768. At maximum frequency, the MVA 1024 supports a resolution over 3½ times greater than standard EGA.

The board uses the TI TMS 34010 graphics processor, and is also EGA-, PGC-, and CGA-compatible. It uses the DGIS (Direct Graphics Interface Standard) and the PGL (Professional Graphics Language). The board was jointly developed by NEC and Paradise Systems.
Price: $1299.
Contact: NEC Home Electronics USA Inc., 1255 Michael Dr., Wood Dale, IL 60191, (312) 860-9500.
Inquiry 798.

IEEE for the PS/2

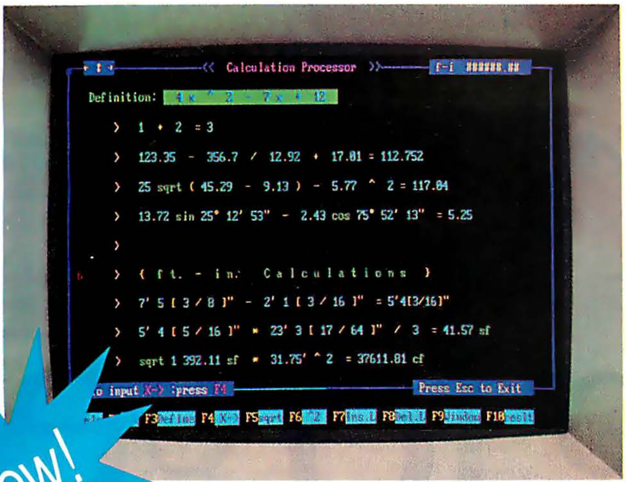
The Personal488/2 and Personal488/2A are IEEE-488 interface boards for the Micro Channel bus of IBM PS/2 computers (Models 50, 60, and 80). The boards offer different maximum data transfer speeds. The Personal488/2 supports data transfers of up to 33K bytes per second; while the 2A model supports up to 1 megabyte per second.

The boards are designed around a proprietary device driver software architecture that the company claims has several advantages including programs that are two to five times shorter, full DOS compatibility, and Hewlett-Packard programming compatibility.

The Personal488/2 also has built-in error checking that's able to stop a program when a syntax error, bus timeout, or other problem occurs. The problem is then identified to you. The IOtech interface provides built-in vectoring on SRQs (service requests), allowing your BASIC programs to automatically act on these conditions without adding polling requests to the programs.

Full IEEE controller compatibility (up to 14 bus devices) is standard. It includes standard IEEE-488 shield connectors, with no special cabling required. There are no DIP switches or jumpers to set, and 488 driver software is included.
Price: Personal488/2, $495; Personal488/2A, $595.
Contact: IOtech Inc., 23400 Aurora Rd., Cleveland, OH 44146, (216) 439-4091.
Inquiry 799.

continued



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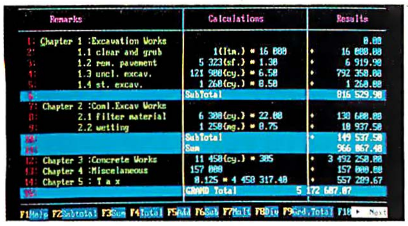
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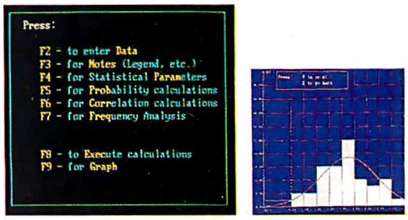
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SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

Clarion Development Environment Offers Bridge to dBASE

Clarion, a development language for writing business-oriented applications, now lets you read and write unaltered dBASE III files without copying or converting them. This capability is the result of the Data Base Three LEM (language extension module). Translator, communications, and DOS and finance language extension modules have already been added. An application generator is planned for the future.

The Data Base Three module lets you convert your dBASE programs to Clarion, and your dBASE files updated with Clarion are also compatible with dBASE III programs. LEM provides file-processing commands for .DBF files that parallel Clarion file-processing commands. Record keys can be the same as those used in dBASE III programs, or they can be unique to the Clarion applications. Clarion updates and maintains indexes during processing, and they are available for subsequent processing by .PRG programs. You can distribute Clarion programs as .EXE programs, with no run-time license.

Clarion requires an IBM PC, XT, AT, PS/2, or compatible with at least 320K bytes of RAM and a hard disk drive. The program is available on 3½- and 5¼-inch disks.
Price: $395 for Clarion; $49.50 for the Data Base Three LEM.
Contact: Barrington Systems Inc., 150 East Sample Rd., Suite 200, Pompano Beach, FL 33064, (305) 785-4555.
Inquiry 800.



Read and write unaltered dBASE III files with Clarion.

Screen Management

Hi-Screen XL is a tool that lets you create language and application screens and windows, save them in separate files, and interface them with the application through a memory-resident module. Screens are language- and application-independent, so you don't have to recompile the program every time you make changes, and you can use the same set of screens with different languages. The module manages cursor moves, data checking, and performs menu-management functions. You can generate and manage windows, menus, screens, and data entry in BASIC, Pascal, C, Cobol, FORTRAN, dBASE, and assembly language.

You can have 26 layers of windows overlapping on one screen, and the total number of windows is unlimited. You can use windows for data entry, menus, or on-line help, and the menus can be pull-down, pop-up, or Lotus-style.

Hi-Screen XL runs on IBM PCs and compatibles with MS-DOS or PC-DOS 2.0 or higher and at least 256K bytes of RAM for screen generation.
Price: $149.
Contact: Softway Inc., 500 Sutter St., Suite 222, San Francisco, CA 94102, (415) 397-4666.
Inquiry 801.

Develop Programs up to 16 Megabytes

DOS/16M was designed as a protected-mode, large-memory environment for C and assembly-language programs with up to 16 megabytes of code. It enables you to develop programs on 80286 or 80386 IBM PC ATs and compatibles under MS-DOS 3.0 or higher, and it can also handle mainframe or minicomputer programs on PC ATs. Rational Systems reports that the program is compatible with many C compilers and linkers.

The program includes a transparent run-time library for managing extended memory and for running programs in 80286 protected mode. It also includes a debugger and source code for the library and start-up code.

For protected-mode addressing, DOS/16M automatically adjusts your program, then switches the computer into protected mode and starts the program executing. DOS/16M can also switch the computer to real mode to handle external interrupts that don't have protected-mode handlers.

DOS/16M lets you handle direct I/O, write directly to video RAM, and use EMS. DOS/16M requires that you fix the parts of your program where it writes into code segments, and you must modify any arithmetic on segment register values.
Price: $5000 for a license to develop up to 200 copies; $10,000 for source code.
Contact: Rational Systems Inc., P.O. Box 480, Natick, MA 01760, (617) 653-6194.
Inquiry 802.

286 Programming Environment

Cito is an interactive Unix-based environment that lets you develop and debug programs with a macro programming language. It enables you to develop programs quickly by calling individual routines from the command-line interpreter with arbitrary arguments for debugging. When an error is discovered, or you need to add more features, you can reload individual object modules into Cito, rather than having to relink the whole program. You can write, edit, compile, and link C procedures from within the Cito environment.

The macro interpreter in Cito generates executable machine code for macro definitions and entry points to dynamically linked procedures. You can also use macro definitions to develop protocols and diagnostics. And Cito supports conditional testing, high-level control structures, file I/O, multitasking, variables, and arithmetic.

Cito runs on the IBM PC AT and compatibles with Xenix System V, 1 megabyte of RAM, and 20 megabytes of disk space. More RAM is recommended for multiuser applications or for developing large programs.
Price: $229.
Contact: Fillmore Systems Inc., 7200 York Ave. S, Suite 301, Edina, MN 55435, (612) 831-6984.
Inquiry 803.

continued



The KODAK DATASHOW™ System for projection of PC images.

Imitations come and go, but the original from Kodak continues to lead in quality and convenience.

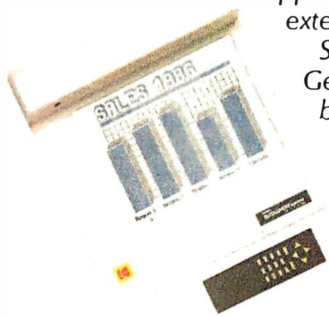
Used with an overhead projector, the Datashow system converts your PC into an interactive, big-screen presentation tool, free of image distortion found in others.

And, unlike some, it permits simultaneous display of real-time images on the PC monitor and projection screen.

This Kodak system also lets you manage presentations with exclusive, multi-use software, wireless remote control, and, new from Kodak, additional software for remote control of application programs like Lotus 1-2-3.

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SOFTWARE • SCIENTIFIC AND ENGINEERING

Simulating Amine Processes

Chemcalc 11: AMSIM (Amine Gas Treating Plant Simulator) models processes for absorption and stripping of H_2S and CO_2 in any type of gas stream.

The program includes processes such as Union Carbide's UCARSOL and SNPA's DEA. The simulator also determines the amount of hydrocarbons absorbed and stripped. It specifies amine circulation, pressure-temperature conditions, the number of theoretical trays, slippage of absorber gas remainder, and stripping limitations.

You need to input only a limited amount of data, including factors such as feed gas range and stripper column pressure. All common amines are included, according to Gulf Publishing, and you can simulate any treating system by inserting the proper constants. To produce true equilibrium with chemical reaction, the program uses the Kent-Eisenberg model.

Chemcalc runs on the IBM PC and compatibles with at least 128K bytes of RAM and a single disk drive.

Price: $795.

Contact: Gulf Publishing Co., P.O.Box 2608, Houston, TX 77252, (713) 529-4301.

Inquiry 804.

Finite-Element Analysis for the Macintosh II and SE

MSC/pal 1.95, a finite-element analysis program for the Macintosh II and SE, lets you analyze designs to determine strength characteristics and dynamic response.

Version 1.95, like the original MSC/pal, uses the finite-element analysis method in which a structure or mechanical component is broken into a number of discrete elements that can be analyzed by a computer for response to stress, vibration, and pressure. Version 1.95 is enhanced with features such as hidden-element plots that show models with solid shading, and shaded contours of display design analyses.

In addition, MacNeal-Schwendler announced that late this year it will release another version of MSC/pal for the Mac II that will take advantage of the machine's 68881 numeric coprocessor, run faster than previous versions, and include a full color display.

Price: $1495.

Contact: MacNeal-Schwendler Corp., 815 Colorado Blvd., Los Angeles, CA 90041, (213) 259-3875.

Inquiry 805.

Numerical Analysis and Equation Solver

Solver-Q lets you solve over 1000 simultaneous nonlinear algebraic equations, symbolically simplify arbitrary equations, solve complex equations, and perform multiple nonlinear regression. You can also reduce equations by symbolically substituting values of desired variables for their equivalent expressions.

The program includes an editor and an on-screen tutorial. It operates in a windowing environment, and you can run it as an add-on to Lotus 1-2-3.

Solver-Q runs on the IBM PC, XT, and AT with at least 256K bytes of RAM and a monochrome or color monitor.

Price: $90; academic, $40.

Contact: Software Development and Distribution Center, University of Wisconsin–Madison, 1025 West Johnson St., Room 1161L, Madison, WI 53706, (608) 263-9484.

Inquiry 806.

Data Acquisition and Process Control

Route 488 is a memory-resident BIOS-level device driver that works with IEEE 488 boards. Using the device driver, your data does not need to go through a DOS Device Handler. Scientific Solutions reports that Route 488 transfers a complete data buffer to the GPIB at rates up to 400 percent faster than moving data through a DOS device handler.

You can access Route 488 from any language running under MS-DOS. The program requires an IBM PC, XT, AT, or compatible with at least 96K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher. It also requires a 488 board.

Price: $125.

Contact: Scientific Solutions, 6225 Cochran Rd., Solon, OH 44139, (216) 349-4030.

Inquiry 807.

SOFTWARE • BUSINESS AND OTHER

Two Databases for the Macintosh

C.A.T. (Contacts, Activities, Time) is a business account-oriented database that organizes information into multiple files and links them together as they are used. The components resemble a phone book (contacts), a to-do list (activities), and a calendar (time). In the contact file you can manage 14 views of your contacts. You custom-design the views to your needs, and C.A.T. checks and adds new contacts to the appropriate views. You also have the ability to add up to 16 pages of notes to each contact and account. Using the zoom feature, you can select an account, and the program automatically shows you all contacts at the account.

Activity fields are also user-designed. You can store preset text for form letters, record phone calls, post facts, and have preset follow-up activities. Every event is automatically stored in contact and time files as well.

You can use your time files to show all your events for a day, week, month, or any specified time period. A search feature lets you select the name of a contact and activity name, and the program fills in the remaining information. You can select events by contact, activity, or time, and you can produce reports based on the information in any of the fields.

With the C.A.T. merge feature you can share data in work groups. Passwords protect the data at the system level, as well as in individual user files. Other features of C.A.T. include integrated windows and free-form text entry. C.A.T. is not copy-protected and works with the Imagewriter, LaserWriter, and AppleShare file server. The program offers limited color support on the Mac II.

C.A.T. runs on the Macintosh 512, 512E, Plus, SE, and II. Finder version 5.3 and System 3.2 are required, and the company recommends a Mac with a 20-megabyte hard disk drive.

Price: $399.95.

Contact: Chang Labs, 5300 Stevens Creek Blvd., San Jose, CA (408) 246-8020.

Inquiry 808.

The database 4th Dimension offers a programming language, layout graphics, and multiuser, runtime, and menu-customizing capabilities for handling large amounts of information. To start out,

continued



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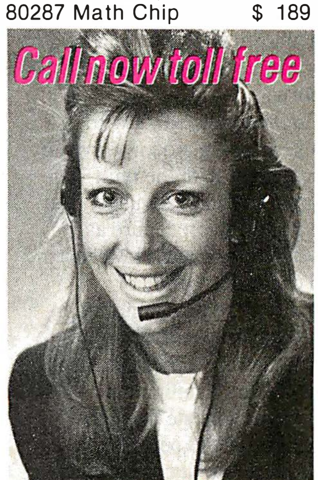
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you build your database in the design environment, where you create files, fields, links, procedures, and design the look of your database. Then you move to the user environment to enter data, search and sort, modify or delete information, and print reports. The custom environment lets you set up your own menus, screens, reports, and procedures.

Like C.A.T., 4th Dimension is windows-oriented and enables you to have several windows open at one time.

Your database can have up to 99 data files accessible simultaneously, and each file can have up to 511 fields. The files are linked so you can update records in other files.

Data in 4th Dimension is entered and displayed through layouts that you design. Eight predefined layouts are included, and you can customize them or create your own. Using a MacDraw-like graphics editor, you can create up to 32,000 layouts for each database. You can also create graphics from your data by opening a window that offers you the fields to graph and the graph types. You can also import and export SYLK, DIF, and text with Macintosh, IBM PC, and mainframe programs, Acius reports.

To manipulate data with 4th Dimension, you must write a procedure with the built-in programming language. You can write any procedure as a text listing or as a flowchart and can use it locally or globally. The programming language has over 200 built-in routines and operators, and allows you to manipulate sets, communicate through serial ports, and perform arithmetic operations on pictures. Programming and debugging tools are also available.

A run-time version of 4th Dimension comes on four disks that enable four people to use a custom database, but not change its design.

Like C.A.T., 4th Dimension runs on the Mac Plus, SE, or Mac II, and the company recommends a hard disk drive.
Price: $695; runtime version, $295.
Contact: Acius Inc., 20300 Stevens Creek Blvd., Suite 495, Cupertino, CA 95014, (408) 252-4444.
Inquiry 809.

Multiuser Desktop Publishing on the Mac

MultiPublisher, a multiuser version of MacPublisher III, enables up to 16 people to simultaneously edit text and graphics on Macintosh workstations. It appears to be a single-user system to each user, except it will alert you when two people attempt to edit the same item or layout something on the same page. Its memory-saving data architecture stores text files and graphics separately from the main publication, allowing you to change text or graphic files and see the changes made globally across the layout.

MultiPublisher is compatible with AppleShare, HyperNet, and other file servers, along with local-area networks such as AppleTalk, TOPS, and PhoneNet, the company reports. MultiPublisher files are compatible with those of MacPublisher III. The multiuser program also has the same capabilities, including rotation of text and graphics in 1-degree increments, color text and graphics, exporting of designs as PICT files, and importing of PostScript files.
Price: $2000 for 4-user version; $3000 for 8-user; and $4000 for 16-user.
Contact: Boston Publishing Systems, 1260 Boylston St., Boston, MA 02215, (617) 267-4747.
Inquiry 810.

HyperCard Applications

Focal Point is a HyperCard stackware business-management system that lets you customize your workday. It includes an appointment calendar, address cards, incoming and outgoing phone logs, a spreadsheet, graph and invoice generator, and other desktop accessories. You can search for data among features and create custom accessories. And you can jump to other Macintosh applications programs and back again with Focal Point's application "launcher."

Focal Point requires at least a Mac Plus, and you must have a copy of HyperCard. (To run HyperCard, you need at least 1 megabyte of memory and either two 800K-byte floppy disk drives or one floppy and a hard disk drive.)

Business Class is another HyperCard program from Activision. It gives you access to travel information on countries around the world. These include currency rates, transportation schedules, current time, climate, holidays, tipping, customs, and language. A built-in telephone interface lets you connect with phone-reservation systems for airlines, hotels, and car rental agencies. You can also print itineraries, maps, and other travel documents.

Business Class also runs on a Mac Plus with HyperCard. Both will ship this quarter, according to Activision.
Price: Focal Point; $99.95, Business Class, $69.95.
Contact: Activision, 2350 Bayshore Parkway, Mountain View, CA 94043, (415) 960-0410.
Inquiry 868.

Integrated Accounting

Layered's Insight All-In-One is an accounting program designed for small businesses and includes accounts receivable, accounts payable, payroll, inventory, job cost, and general-ledger modules.

The number of customers, vendors, employees, and transactions is limited only by your disk space. You can print reports and lists to the screen. The accounts receivable module enables you to perform open-item tracking, access customers by name and have up to 99 line items on an invoice. You can calculate sales tax automatically, distribute invoices to up to 255 ledger accounts and 255 projects, and produce summary and detailed aging reports.

The accounts payable module lets you enter purchases when you receive vendor invoices. You can print checks and W-2 forms, pay vendor invoices partially or fully, and produce summary and detailed aging reports for vendors.

The general ledger supports up to 9999 accounts with a four-digit account number. You can only post balanced transactions, and you can distribute journal entries to projects or profit centers.

The payroll module provides built-in tax tables. You can process hourly and salaried payrolls, and track hourly wages, salaries, tips, commissions, and benefits.

With the inventory module you can value inventory by average-weighted-cost method, enter adjustments and transfers, and produce a report with analysis of sales, cost, and gross profit margin.

Insight All-In-One runs on Macs with at least 512K bytes of RAM and two 800K-byte floppy disk drives.
Price: $595.
Contact: Layered, 529 Main St., Boston, MA 02129, (617) 242-7700.
Inquiry 869.

REGIONAL SECTION

METRO NEW YORK • NEW ENGLAND

Okidata Upgrades Microline

The 182 Plus is Okidata's latest incarnation of its Microline printer series. This 9-pin dot-matrix unit prints at 180 characters per second in high-speed draft mode, 120 cps in "utility" mode, and 30 cps in near-letter-quality mode.

Okidata claims the 182 Plus has a mean time before failure of 4000 hours and a rated print-head life of 200 million characters.

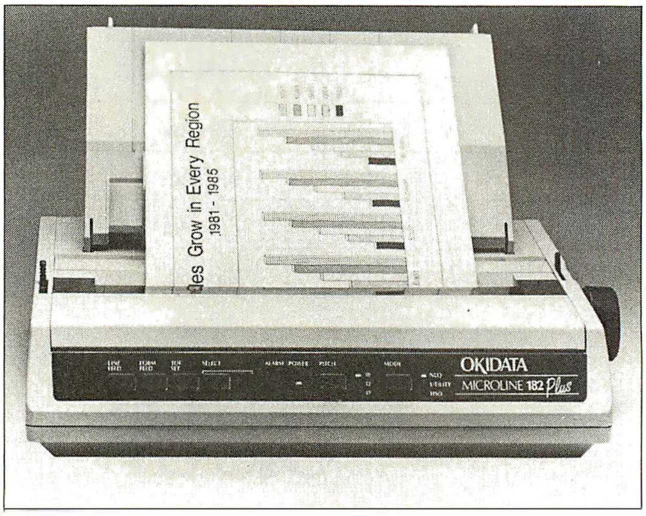
A self-inking "clean hands" ribbon cartridge is rated for 3 million characters.

Using front-panel switches, you can select print mode and pitch of 10, 12, or 17 characters per inch. The 182 Plus weighs 9.9 pounds and has a 1-square-foot footprint. It operates at a noise level of 57 adjusted decibels.

Price: $319.

Contact: Okidata, 532 Fellowship Rd., Mount Laurel, NJ 08054, (609) 235-2600.

Inquiry 870.



Okidata's updated 182 Plus prints at 180 cps.

RGB-to-NTSC Encoder

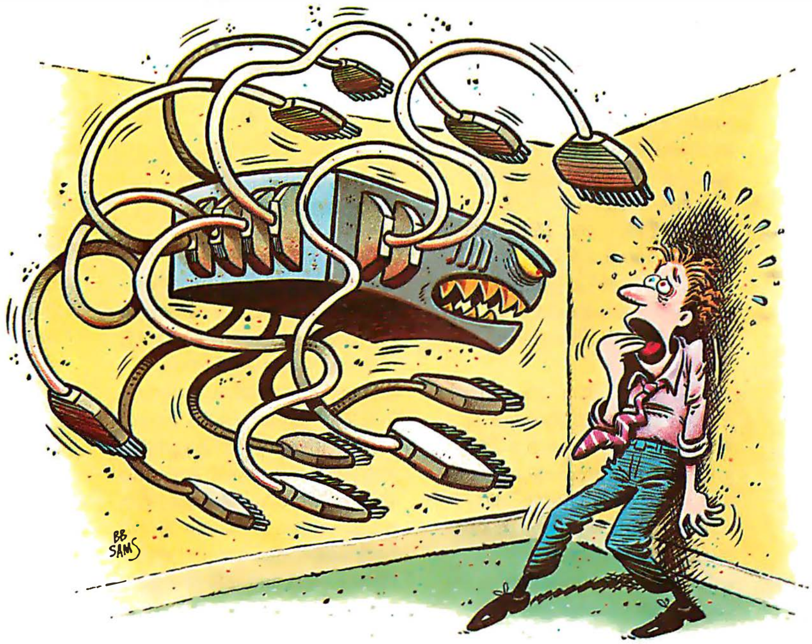
Communications Specialties' ENC-3 lets you convert standard analog RGB with sync-on-green signals to standard NTSC composite video signals. The ENC-3's output is compatible with VCRs, large-screen projection TVs, and composite video monitors.

The ENC-3 locks color burst to sync, minimizing chroma crawl on vertical color edges. It has its own AC power supply, 9-pin DIN female input connector, and BNC female output connector. It can drive a 75-ohm load.

The ENC-3 works with most graphics boards and terminals. Two interface cables are available: a 6-foot

continued

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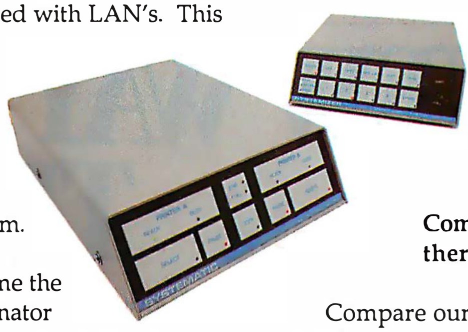
If you're thinking about sharing printers via a multi-port printer sharing box, we've got an alternative for you— one that's been proven to be superior by thousands of major corporate and government PC decision makers.

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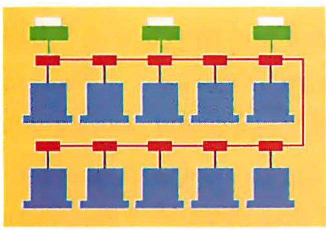
Our Systemizer and Systematic are **networking printer buffers**. As with any printer buffer, there's an input for a computer and an output for a printer. But unlike any other printer buffer, these have a third connector that lets them link together to form their own Local Area Network. Up to 15 computers, when each is equipped with a Systemizer or Systematic, can share from 1 to 15 printers. This accomodates systems ranging from those where every user has his own printer to those where everyone is sharing a single printer, and every variation in between. That's versatility!

They're compatible with practically any piece of equipment too: PC's, engineering workstations, terminals, mainframes, modems, plotters, laser printers... anything with a standard parallel or serial connection. Not only does this help insure compatibility but it also gives you total flexibility as to equipment placement.

But the real beauty comes from the way these pups are linked together in their own LAN. Our network can extend as far as 1200 feet—try that with a multi-port octopus box (the wiring bill alone would kill you)! Also note that **our buffers are networked—*not* your** computers. This means there are none of the hardware and software compatibility problems associated with LAN's. This also means any mix of computers and printers, of almost any brand or model, can participate in this sharing system.



In effect our system will become the common denominator by which all your equipment can connect, in any configuration and location you desire, now and in the future.



Ex. 10 computers sharing 3 printers.

Performance & Reliability

Our *distributed processing* approach to printer sharing distributes the workload. Each user has his own high speed microprocessor, buffer memory and easy-to-use control panel—dedicated to handling just his work. Compare this to a single multi-port sharing box, with its single processor, creating a bottleneck as it tries to simultaneously keep up with data coming from several computers *plus* feed data to one or more printers. Which is more appropriate for today's high speed computers and laser printers?

Another benefit of our distributed sharing system is its high degree of fault tolerance. Again, compare our method to a single multi-port box. When one of those breaks down every user in the entire office goes down with it. Isn't this called "putting all your eggs in one basket"?

Compare and find there's no comparison...

Compare our flexibility to a single multi-port box with its limited number and kinds of inputs and outputs. Compare our compatibility, performance and reliability. Then you'll see why hundreds of multinational companies and many departments of our Federal Government have chosen Systemizers and Systematics as their standard printer sharing solution.

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coaxial cable with male BNC for mating output to an RCA phono plug, and a 4-foot coaxial cable that runs from the ENC-3 to three male BNC plugs. The ENC-3 measures 3 by 5.8 by 2 inches.
Price: $395.
Contact: Communications Specialties Inc., 6090 Jericho Turnpike, Commack, NY 11725, (516) 499-0907.
Inquiry 871.

ROMulator Emulates ROMs

The ROMulator is an in-circuit ROM emulator that assists you in developing software that runs in ROM without continually burning and erasing ROMs. It emulates ROMs from a 2716 to a 27512 and a ROM blaster, letting you download software from a host system without shutting off the target system. Eight models are available. The S model is a single module for one ROM; D provides master and slave modules for two ROMs; the 256 emulates 16K-, 32K-, 64K-, 128K-, and 256K-bit ROMs; and the 512 adds 512K-bit ROM emulation to the 256. Each model is also available with nonvolatile features.

The ROMulator connects to your computer through an RS-232C port. Two RS-232C ports are required—you need one for daisy-chaining. All models come with one or two 8-inch ROM cables, software, and a modular cable with adapter.
Price: Single-ROM emulation models, between $400 and $675; double-ROM emulation models, between $650 and $1100.
Contact: Grammar Engine Inc., 1021 Tipton Court, Westerville, OH 43081, (614) 882-6366.
Inquiry 872.

Multilingual Word Processing

Intext is a multilingual word-processing program that lets you work with multiple languages simultaneously.

Intext starts with one language in residence when you load the program. To work with another language, you press a function key, and the keyboard is automatically reconfigured. You can switch back and forth, and integrate right-to-left and left-to-right languages.

Menus, help messages, and manuals are available in native languages. You can identify the position of foreign characters on your keyboard with layout guides, stickers, and key caps, or use keyboards with LCDs. The program supports C.O.S. Computer Technology's LCD keyboard.

Intext languages include Arabic, Chinese, Danish, Dutch, American and British English, Farsi, French, French Canadian, German, Greek, Hebrew, Italian, Polish, Portuguese, Russian, Spanish, Turkish, Urdu, and Yugoslavian. A spelling checker is optional.

Intext runs on the IBM PC and compatibles with 384K bytes of RAM. It is available on either 5¼-inch or 3½-inch floppy disks.
Price: With two languages, $195; with three languages, $250; Jet:Spell multilingual spelling checker, $50 per language.
Contact: Intex Software Systems International Ltd., One Penn Plaza, Suite 4330, New York, NY 10119, (212) 750-1140.
Inquiry 873.

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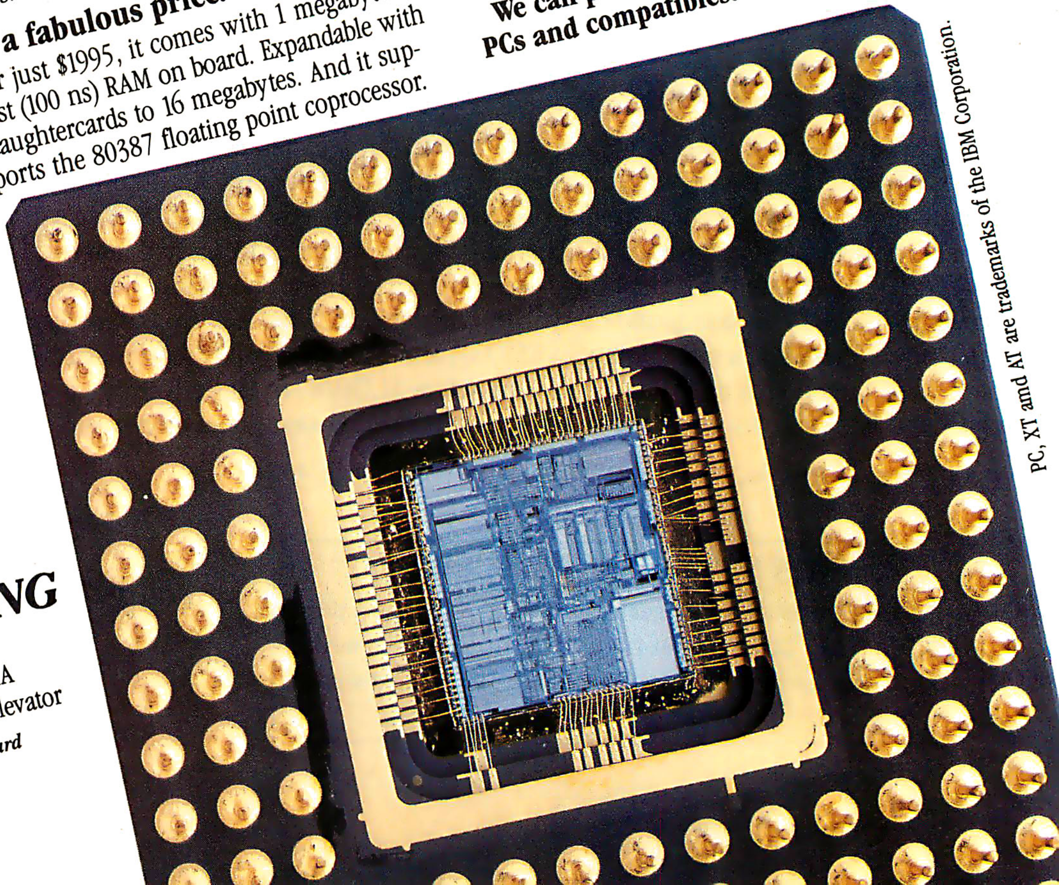
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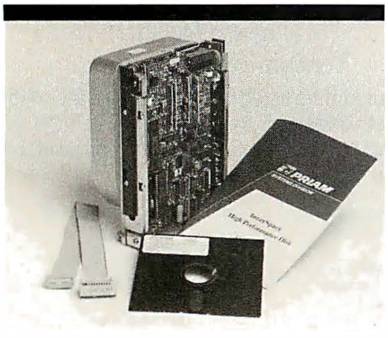
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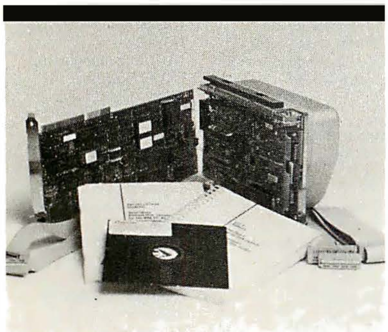
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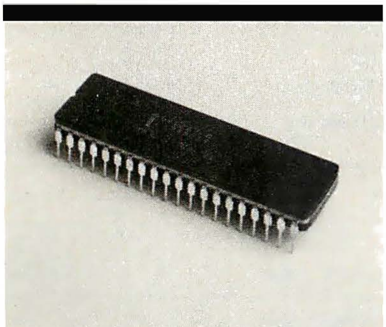


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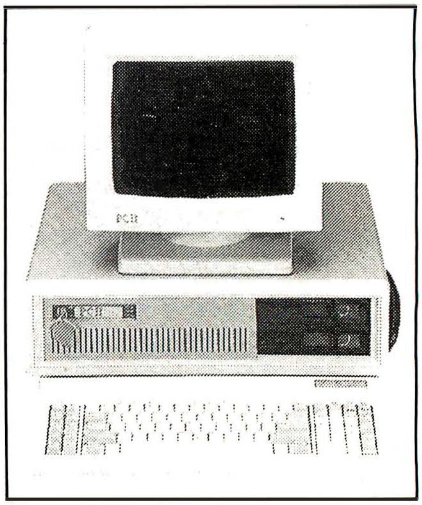
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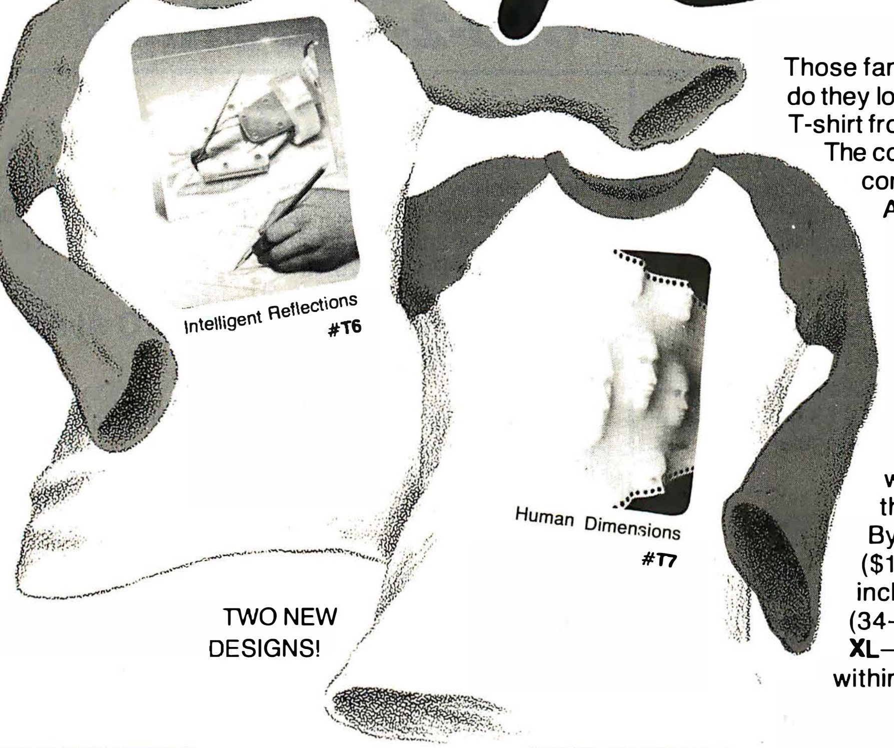
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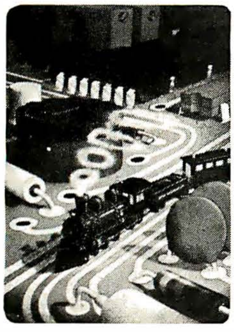


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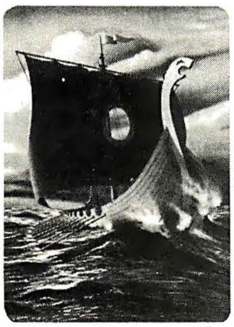
And don't mistake this for a rubbery patch that cracks and peels off after a few washings. This is true four-color process: the permanent inks are silk-screened into the fabric, resulting in a beautiful, full-color image that lasts!

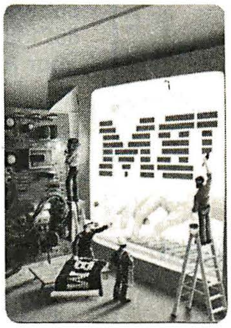
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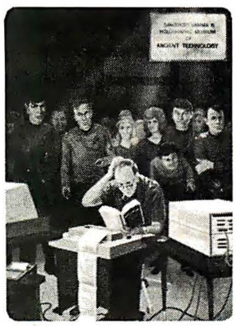
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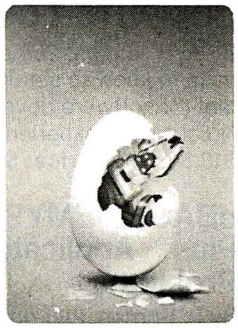




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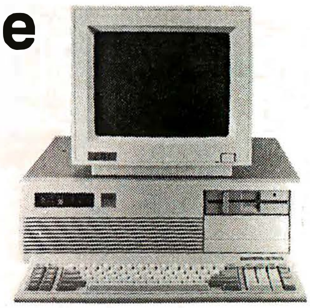
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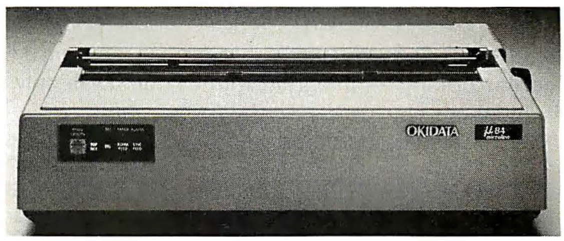
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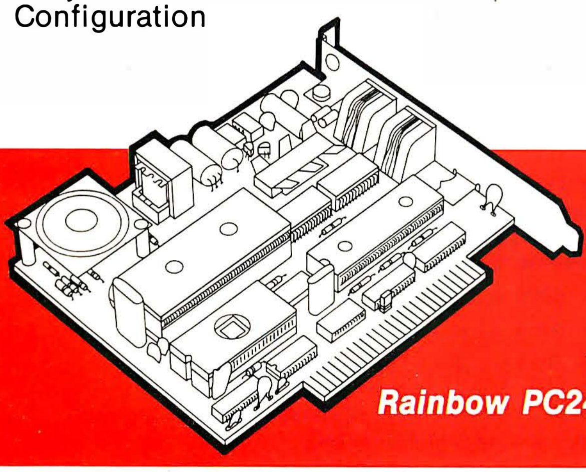
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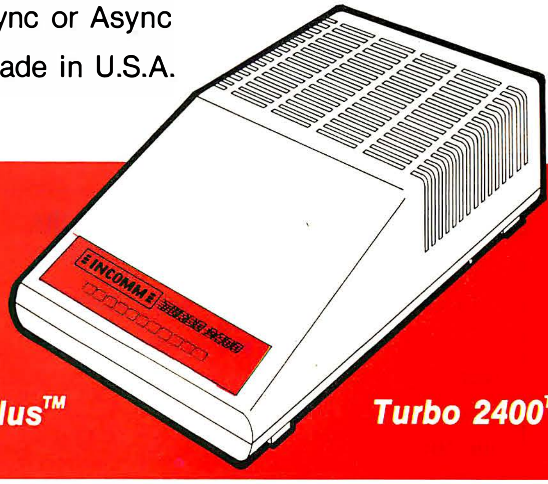
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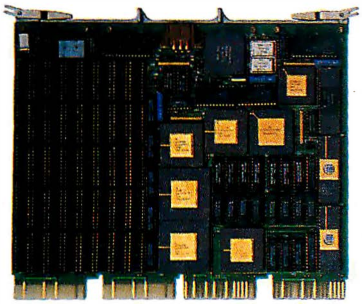
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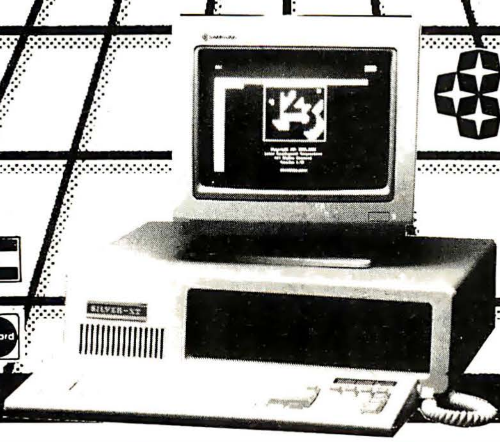
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BYTE editors offer hands-on views of new products.

Turbo Pascal 4.0

Borland International's new version of its popular Pascal compiler for MS-DOS computers has features that will be of particular interest to professional programmers. Most important, 4.0 allows the creation of EXE files, which can exceed 64K bytes; previous versions could generate only COM files, which are limited to 64K bytes. Now programmers of large applications won't have to resort to using memory overlays so frequently. I tested a preliminary version of the product.

Turbo Pascal 4.0 ($99.95) also provides a more complete development environment than its predecessors. Programs can be broken up into modules called units, which can be separately compiled and stored in unit libraries. The maximum size of a unit is 64K bytes. When a main program is compiled, Turbo Pascal locates all the declared units and links them together to form a single executable program. A "unit librarian" takes care of the details of finding and linking units at compile time. The `make` command recompiles only those units that have been modified since the last compilation; the `build` command recompiles all the referenced units.

Standard units included with Pascal 4.0 are `system`, `crt`, `dos`, `printer`, and `graph`. These units are kept together in a single file and are automatically loaded. A utility program lets you add or remove units from this core module.

The user interface has windows and pull-down menus. In operation, it closely resembles other recent Borland products, such as Turbo BASIC and Eureka. An alternate command-line interface is also available for batch mode work.

In addition to Pascal's real and integer numeric data types, Turbo Pascal 4.0 supports data types defined in the IEEE Standard 754. In all, there are six integer data types (`byte`, `shortInt`, `integer`, `word`, `longInt`, and `comp`) and three floating-point data types (`single`, `double`, and `extended`). The compiler provides support for an 80x87 numeric coprocessor, and emulation if one is not present. However, the new floating-point types are available only when compiling and running on an 80x87-equipped machine.

Borland says that conditional compilation (symbols only, no expressions) will be available in the final version of 4.0. One obvious need for conditionals would be to choose between two sets of numeric declarations, depending on the presence or absence of an 80x87 numeric coprocessor.

Turbo Pascal 4.0 provides a much-improved interface to the operating system through the `dos` unit, which handles calls to BIOS routines, use of the 8088's registers, interrupt requests, execution of the DOS shell, date and time commands, disk status functions, and so on.

Borland says version 4.0 will outperform previous versions in compilation speed and efficiency. I compared 3.0 and my preliminary version of 4.0 in compiling the CALC.PAS program provided with Turbo Pascal. On a 4.77-MHz IBM PC with 512K bytes of RAM and an 8087 co-processor, version 3.0 took 15 seconds to compile the 1272-line program. Turbo Pascal version 4.0 took just 10 seconds to compile a slightly different 1273-line version of CALC.PAS.

—George A. Stewart

The Facts:

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XyWrite III Plus

XyWrite III Plus ($445) is XyQuest's latest word-processing program. It adds a spelling checker, a thesaurus, redlining capability, hidden notes, and file inclusion to an already powerful word processor. (See the review of XyWrite II Plus by Rubin Rabinovitz in the September 1985 BYTE.)

The spelling checker provides fast access to a 100,000-word dictionary, and the thesaurus can supply 15,000 key-words and 220,000 synonyms. The spelling checker lets you check an individual word, a block of defined text, or an entire file. Also available is an autocheck mode, in which each word is checked as you type it, and a beep is sounded if the spelling checker catches an error. You can then either ignore the beep, correct the word yourself, or press Control-F to get some help from the spelling checker.

When the spelling checker finds an unfamiliar word, it gives you the option of adding it to either a temporary dictionary or a personal dictionary, which can hold up to 10,000 words. If you type a long phrase regularly, you can specify an abbreviation for the phrase in your personal dictionary, along with the replacement for it. You can then enter a replace mode, and the spelling checker will automatically replace the abbreviation with its expanded form after you type it.

The redlining feature helps you keep an on-screen record of any additions or deletions you make to a file. When you turn redlining on, any deletions you make appear in reverse mode; any additions appear in bold. There is no preview mode, so when you're using the redlining feature the screen can get a little busy.

The label command lets you embed notes in text that don't disturb the flow of text or appear in printer output. (The note appears as a reverse-video superscript *n* followed by the first four characters of the label field. To read an embedded label, you position the cursor over the superscript *n* and then press Control-F3.) A file-inclusion feature lets you incorporate any ready-to-print DOS file, such as spreadsheets, drawings, business graphics, and databases, within a document.

continued

Pressing Control-M gives you a memory-usage menu that lists the components of XyWrite you can unload to free up memory, such as the help files, spelling dictionary, and others.

Other additions to XyWrite III Plus include a word-count program, a sort program that lets you sort a defined block or a file (each entry to be sorted must end with a carriage return), and new function calls that work with the spelling checker, the redliner, the memory-usage menu, and toggling between the overstrike and insert mode. When fully loaded, XyWrite III Plus requires 384K bytes of memory.

XyWrite III Plus is an improvement over the previous versions; the previous versions are low-cost alternatives. XyWrite III 3.1 sells for $395; XyWrite II Plus costs $295.

—Eva White

The Facts:

XyWrite III Plus
$445

XyQuest Inc.
P.O. Box 372
Bedford, MA 01730
(617) 275-4439

Requirements:
IBM PC or equivalent; 256K bytes of RAM (minimum); MS-DOS or PC-DOS 2.0 or higher; one floppy disk drive; monochrome or graphics adapter
Inquiry 852.

Daily Wheel, Scientific Wheel, and Professional Wheel

Dalin Inc. has introduced a series of three packages for doing mathematical calculations on the IBM PC and compatibles. Company founder Joseph Dalin calls them calculation processors—mathematical equivalents of word processors—and predicts this genre will become part of the basic software of personal computers within a few years. I got an advance look at all three packages.

The packages are Daily Wheel ($69.95), Scientific Wheel ($79.95), and Professional Wheel ($158.95). The basic idea of all three is to provide a convenient tool for doing calculator-type work on a personal computer while taking full advantage of the computer's graphics, storage, and text capabilities to produce a more versatile medium for calculation.

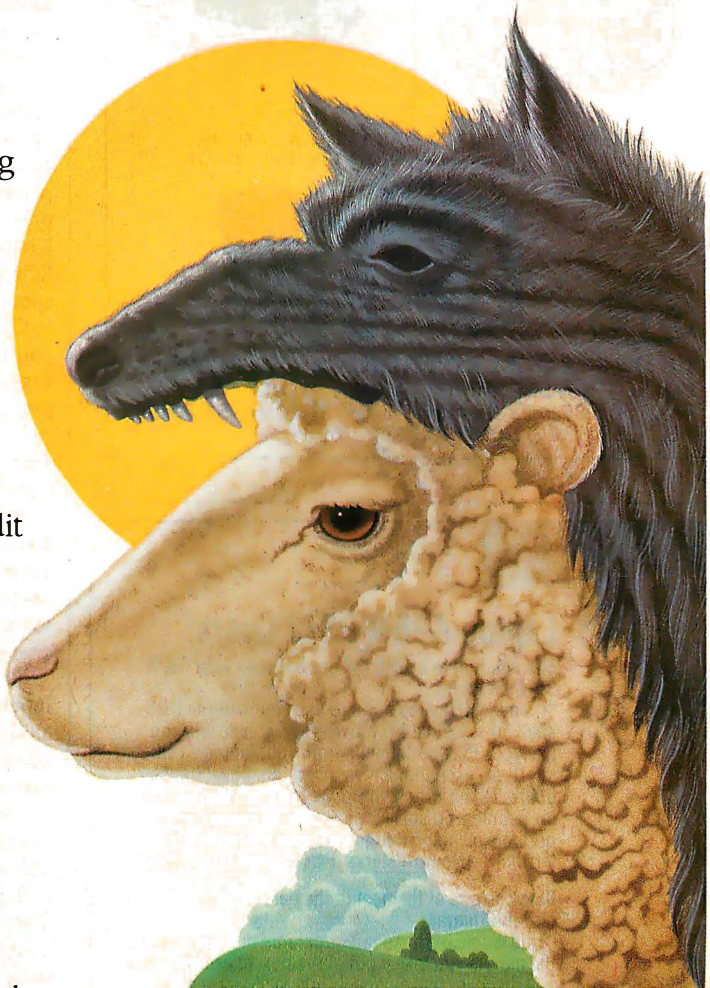
Daily Wheel and Scientific Wheel include memory-resident (pop-up) calculation and unit-conversion utilities. The pop-up programs work with Lotus 1-2-3, dBASE III, WordStar, and other applications that do not use hot keys. Daily Wheel also includes a non-memory-resident calculation editor—basically a scratch pad for performing and storing up to 200 lines of computations, with the ability to take subtotals, totals, and grand totals on the results. Scientific Wheel includes a non-memory-resident function-analysis module for exploring functions of one variable.

Professional Wheel is a set of non-memory-resident programs: the calculation editor, a function calculator, an extended unit-conversion program, and a statistical analysis program for two-variable data sets with up to 200 observations.

The pop-up programs in Daily Wheel and Scientific Wheel offer some unusual features that make them easy to learn and use. For instance, the calculation processor (both versions) accepts dimensional data entered in units of feet and inches, square feet, and cubic feet and performs the calculations automatically, rounding to the nearest minimum measurement unit. Scientific

continued

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Wheel's calculation processor goes beyond that of Daily Wheel, including a comprehensive set of trigonometric, exponential, and logarithmic functions.

The function-analysis program that comes with Scientific Wheel is well suited for students and scientists interested in exploring the properties of functions of one variable. To use the program, you start by defining *y* in terms of *x*; for instance, you may type `y=sin(8!πx)/x` (pressing Alt-p produces the symbol π). Then you define the limits of evaluation for *x*, say, -π to π, and, optionally, the limits for *y* (used in clipping the graph). Now you press F4. The program analyzes the function, finding all the "special points": *y*-axis crossings, *x*-axis crossings, local minima and maxima for *y*, and asymptotes (regions where *y* tends to ± ∞). The results of the analysis are printed in a table.

When the analysis is complete, you can press F9 to graph the function (a graphics adapter is required). The graphs are scaled and labeled in detail, so you can precisely locate points of interest. In addition, the special points are indicated by a different kind of dot. (In terms of information presented, Scientific Wheel's graphs are superior to those produced by Borland's Eureka, which have only minimal labeling of points and no control over the *y*-axis clipping.) Scientific Wheel achieves its excellent graphs by using special small-matrix fonts to display text in the graphics mode.

Combining the function analysis table with the graph, you have a very quick and powerful tool for exploring functions of one variable. For further exploration, the program computes derivatives of the defined function at any point and also integrates the function over any interval you specify. Derivatives and integrals are calculated through numeric approximation techniques.

Professional Wheel includes the calculation editor, which has a function calculation module for predefining functions and constants to incorporate into your calculations; an extended unit-conversion program to handle common unit conversions and velocity, discharge, density, viscosity, pressure, power, and energy; and the statistical-analysis program.

The statistical-analysis program allows keyboard or disk input of two-variable data sets and performs the following analyses: the standard parametric measures, probabilities, correlations, and frequency analysis. The program generates a variety of reports and linear or logarithmic graphs.

The Wheel packages are written in Turbo Pascal and assembly language. They use the 80x87 numeric coprocessor, if one is present in your system, or they emulate it if it is not.

The Wheel programs are economical and convenient. They do not provide all the functionality of more expensive programs like Eureka or TK Solver Plus, but within their domain they are a bargain.

—George A. Stewart

The Facts:

Daily Wheel
$69.95
Scientific Wheel
$79.95
Professional Wheel
$158.95

Dalin Inc.
16421 Clymer St.
Granada Hills, CA 91334
(818) 360-7058

Requirements:
IBM PC, XT, AT, or compatible; Daily Wheel/Scientific Wheel: 256K bytes of RAM; Professional Wheel: 384K bytes of RAM; MS-DOS or PC-DOS 2.0 or higher; IBM CGA/EGA or Hercules Graphics Adapter.
Inquiry 853.

continued

Hauppauge 386 Motherboard

For those of us who are still using old IBM PCs and XTs, the 386 Motherboard ($1495) from Hauppauge Computer Works sounds like an answered prayer. The XT-size motherboard has AT-style compatibility and 386 power. The board contains a 16-megahertz 80386 microprocessor, 1 megabyte of memory, a socket for an 80387 coprocessor, and eight expansion slots, two of which can accommodate 16-bit cards designed for the IBM PC XT 286.

The 1 megabyte of memory is four-way-interleaved with a speed of 100 nanoseconds. A proprietary 32-bit memory-expansion socket is also present. The company plans to deliver 4- and 12-megabyte memory cards for the board.

At the time of this writing, an IBM PC XT version of the board was available, and Hauppauge claimed that a PC version would be out shortly. I tested the XT board with an old IBM PC. With impressive ease, a Hauppauge representative took my PC apart and removed the motherboard. He then quickly installed a new power supply, but a problem surfaced immediately. Being an XT version, the keyboard connector and slots on the board did not line up with the external opening in the rear panel of the PC.

I was told that the PC version of the board would have the correct keyboard connector but would retain XT-style expansion slots. For testing purposes, I decided to install the board without reattaching the PC's external case, since that was the only way to connect the keyboard to the system. Then another problem surfaced: The 386 board would recognize the hard disk drive I had added to my PC, but not the PC's own floppy disks. I couldn't figure out why.

Later, a representative from Hauppauge said this problem occurred on another old system, this time an XT. The rep said he thought the problem has something to do with IBM's floppy disk controller. Fortunately, Hauppauge says it offers a 30-day money-back guarantee.

In any case, I did get the system running off of the hard disk drive, and it was impressive.

I tried the board on a simple recalculation test, using Paperback Software's VP-Planner and Microsoft's Multiplan. On VP-Planner, the test ran 10.5 times faster than usual. With Multiplan, which made use of the board's optional 387 numeric coprocessor ($500 extra), the test ran 22.6 times faster.

Note that this was not a comprehensive test by any means. But I was impressed by the price/performance of this board and was assured by the company that on more than 300 installations on XTs, only one had had the disk problem.

The Hauppauge 386 Motherboard seems primarily designed for XT owners. PC owners will need a new power supply and may be better off spending a little more money to get a complete new system. However, for those with an XT, the Hauppauge board appears to be an extremely cost-effective way to upgrade their systems to state-of-the-art performance.

—Rich Malloy

The Facts:

Hauppauge 386
Motherboard
$1495

Hauppauge Computer Works Inc.
358 Veterans Memorial Highway
Commack, NY 11725
(516) 360-3827

Requirements:
IBM PC XT
Inquiry 854.

continued

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Colorizer 1.0

Colorizer ($49.95) is a group of utilities that lets you add color to your Mac II environment—to windows, dialog boxes, or PICT documents, for example. Although the Mac II supports color, very few applications currently make use of this feature. Ultimately, this will change, but in the interim, Colorizer is an attempt to fill the void.

The Colorizer package consists of a 69-page manual and an 800K-byte 3½-inch disk. On the disk are a Control Panel "cdev" called Colors, two FKEYs, the Colorizer application, Apple's Installer application, and Installer script files.

To access the Colors cdev, you activate the Control Panel desk accessory and click on the Colors rainbow icon. Colors will display four subpanels that modify the colors of the windows and the controls, select the color used for highlighted text, modify the Mac II's color palette by selecting which 256 colors (out of 16 million) you want to display, and allow you to set up a MacDraw-style PICT file as a color start-up screen.

Colors offers a number of "canned" color settings for windows, or you can create your own. The option to modify the color palette will be useful to someone with exacting demands in artistic design or CAD/CAM.

The `Color SaveScreen` and `Color PrintScreen` are FKEYs that allow you to capture a color screen to a file or dump it to an Imagewriter II printer by typing a special keyboard sequence. The `Color PrintScreen` FKEY seems to work only with an Imagewriter II; I couldn't get it to print to either an Imagewriter or a LaserWriter. Palomar Software says a new version that corrects this problem will be released soon.

The Colorizer application is an object-oriented drawing program similiar to MacDraw, but it lets you manipulate the objects in color. You can draw, group, or ungroup objects, as well as select a foreground or background color.

—Tom Thompson

The Facts:

Colorizer
$49.95

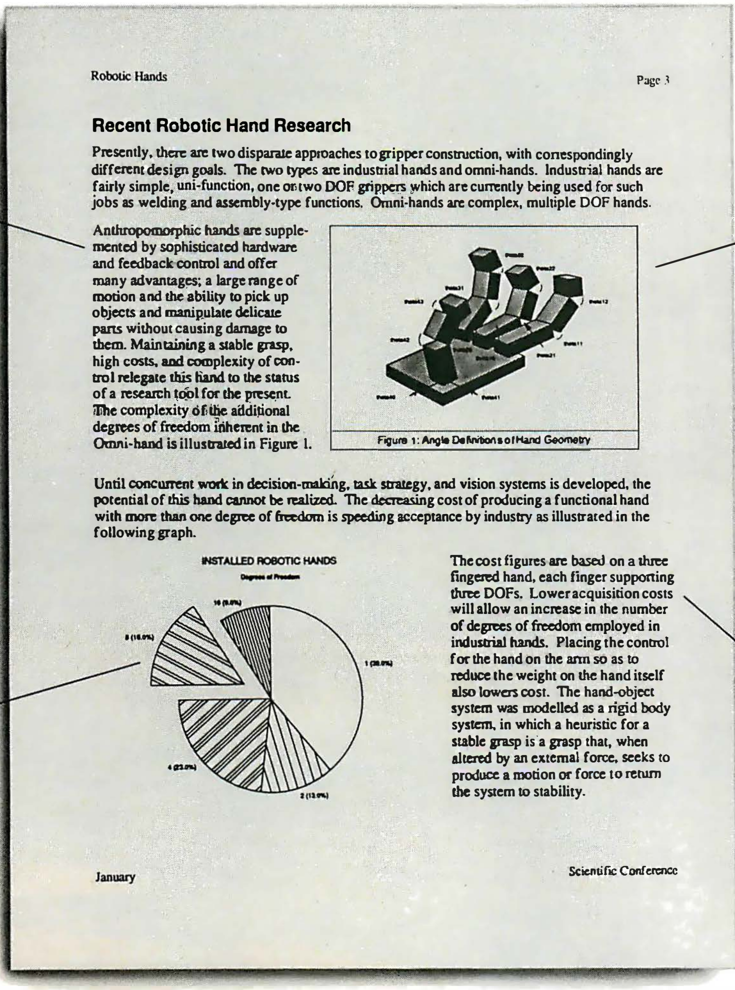
Palomar Software Inc.
P.O. Box 2635
Vista, CA 92083
(619) 727-3922

Requirements:
Macintosh II with 2 megabytes of RAM and 512K bytes of video RAM; color monitor recommended
Inquiry 855.

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Robotic Hands   Page 3

Recent Robotic Hand Research

Presently, there are two disparate approaches to gripper construction, with correspondingly different design goals. The two types are industrial hands and omni-hands. Industrial hands are fairly simple, uni-function, one or two DOF grippers which are currently being used for such jobs as welding and assembly-type functions. Omni-hands are complex, multiple DOF hands.

Anthropomorphic hands are supplemented by sophisticated hardware and feedback control and offer many advantages; a large range of motion and the ability to pick up objects and manipulate delicate parts without causing damage to them. Maintaining a stable grasp, high costs, and complexity of control relegate this hand to the status of a research tool for the present. The complexity of the additional degrees of freedom inherent in the Omni-hand is illustrated in Figure 1.

Figure 1: Angle Definitions of Hand Geometry

Until concurrent work in decision-making, task strategy, and vision systems is developed, the potential of this hand cannot be realized. The decreasing cost of producing a functional hand with more than one degree of freedom is speeding acceptance by industry as illustrated in the following graph.

INSTALLED ROBOTIC HANDS

The cost figures are based on a three fingered hand, each finger supporting three DOFs. Lower acquisition costs will allow an increase in the number of degrees of freedom employed in industrial hands. Placing the control for the hand on the arm so as to reduce the weight on the hand itself also lowers cost. The hand-object system was modelled as a rigid body system, in which a heuristic for a stable grasp is a grasp that, when altered by an external force, seeks to produce a motion or force to return the system to stability.

January   Scientific Conference

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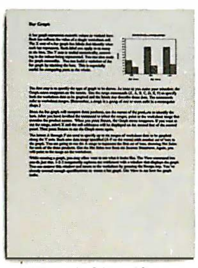
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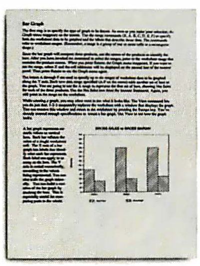
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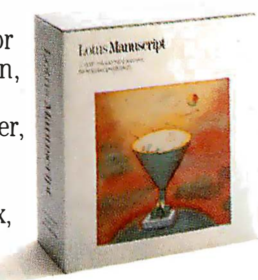
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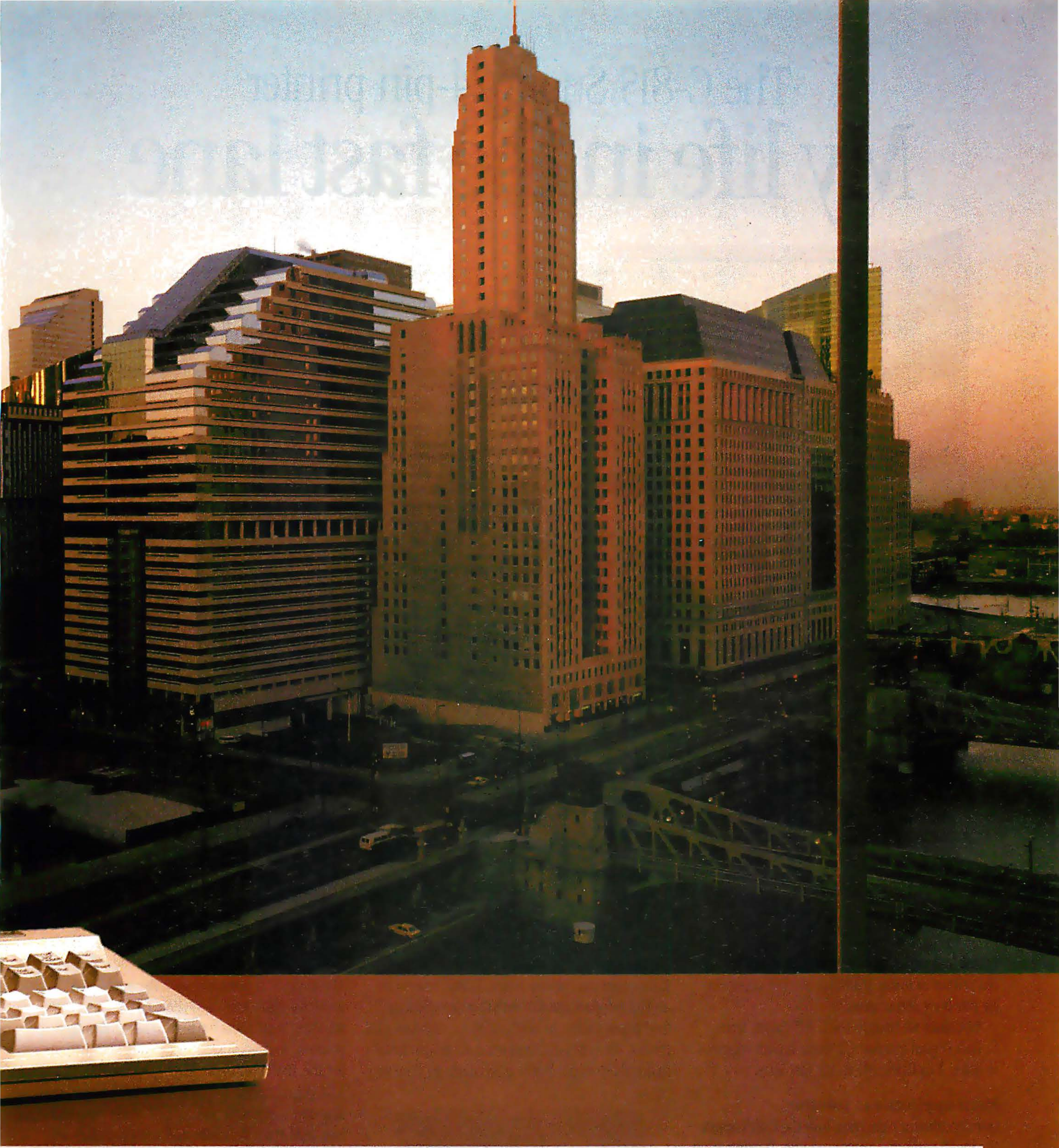
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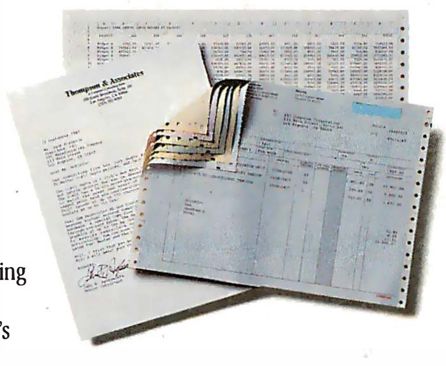
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by the BYTE Editorial Staff

NEW GENERATION

MPW Compiler Lets Mac II's 68020 Shine

The numbers show a lot, but they hide a lot as well

Compilers play a crucial role in the speed of microcomputer systems. A slick compiler can make a good machine shine and can go a long way toward compensating for slow silicon in a lesser machine.

But with so many C compilers for the Mac II available now, you wind up in a juggling contest of compiler and system characteristics when looking for the combination that will suit your needs.

To show how the right combination can make all the difference: The Mac II with its standard 68881 running the MPW C compiler version 2.0 is roughly equal in speed to the Intel 80386-based machines equipped with the optional 80387 math coprocessor running MetaWare High C version 1.3. The results of most of the benchmarks being close calls, the Mac II proved much faster performing the Savage benchmark, while the Model 80 did significantly better on the Dhrystone test (see table 1).

The results for the Float benchmark are included for completeness but don't really reflect the speed of the floating-point operations on the Mac II because the MPW C compiler removed the multiplication step from the loop (it was an invariant subexpression). Again, the addition of a more efficient compiler wipes out the apparent speed disadvantages visible in earlier tests.

We've tested the Macintosh II with several C compilers released just after our September issue went to press. More will come in the months ahead, and we'll continue to make our test results available as we go along. We'll be rerunning the December benchmarks with MetaWare High C 1.4 on 80386 machines, and we'll be testing the 20-megahertz Sun 3/60 workstation with a Sun C Compiler.

From our tests of the new 20-MHz Compaq Portable 386 (see table 2), it's clear that clock speed matters as much as code quality. So, when we test the 20-MHz 68020 system from Sun, both the compiler and the clock speed will be new to our 68020 benchmarking experience. ■

Table 1: *Benchmark figures for the Macintosh SE and II running under various configurations with four different C compilers. All times are in seconds except for the Dhrystone benchmark, which represents Dhrystones per second.*

	Mac SE (Consulair)	Mac SE w/Prodigy (MPW)	Mac SE w/Prodigy (Consulair)	Mac SE w/Prodigy (Manx)	Mac II (Consulair)	Mac II (Manx)	Mac II (MPW)
Dhrystone	574	3278	2380	2176	2106	1829	2861
Fibonacci	263.54	48.58	71.45	71.65	83.72	71.65	52.35
Float	230.23	N/A*	2.61	2.35	2.63	2.35	N/A*
Savage	1921.00	3.42	5.22	3.68	5.42	3.68	3.40
Sieve	64.56	4.73	14.83	11.98	16.72	11.98	4.81
Sort	103.82	7.17	20.41	24.95	23.20	24.95	7.55

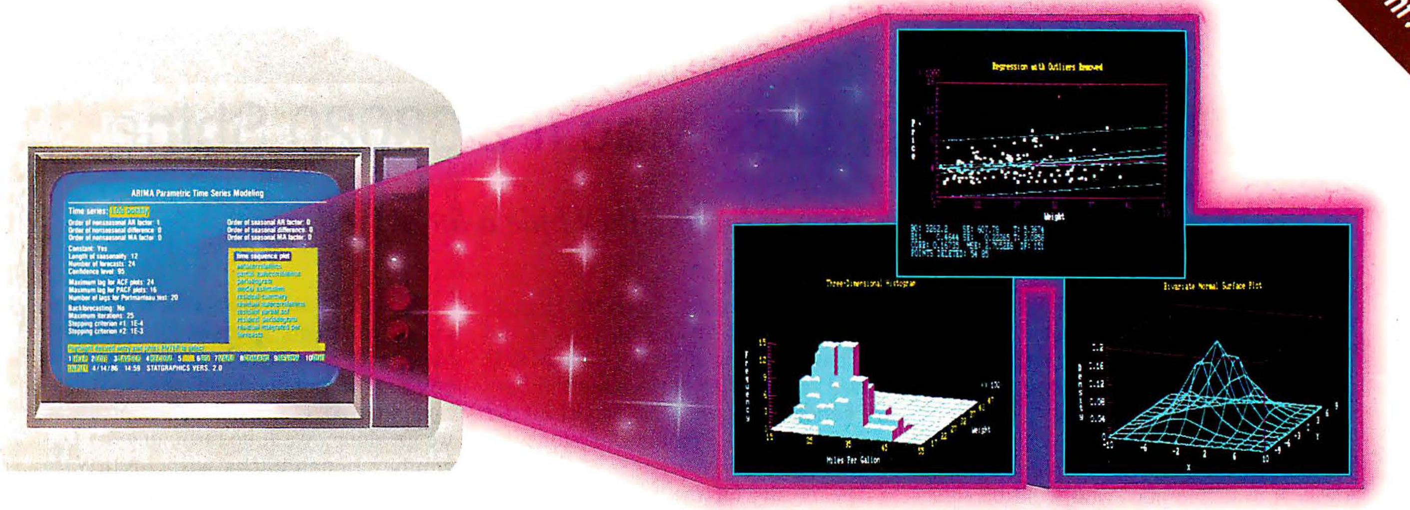
* The results for the float benchmark don't really reflect the speed of floating-point operations on the Mac II and SE because the MPW C compiler removed the multiplication step from the loop. But for the record, the times were 0.64 for the Mac II, and 0.68 for the SE.

Table 2: *Benchmark figures for 80386 machines. All tests were done with MetaWare's High C 386 compiler version 1.3, except for the PC AT, which was tested with the same compiler with no 80386 support. Phar Lap's 386|LINK was the linker used (again, except for the PC AT, which used Microsoft's LINK version 3.51). We used RUN386 version 1.1e for the 80386 machines (as required by High C), except for the Model 80, which required version 1.1. All times are in seconds except for the Dhrystone benchmark, which represents Dhrystones per second.*

	IBM PC AT 8-MHz 80287	Model 80 16-MHz 80387	Compaq Deskpro 8-MHz 80287	Compaq Deskpro 16-MHz 80387	Compaq Portable 386 20-MHz 80387
Dhrystone	1590	3626	3748	3748	4699
Fibonacci	126.22	57.26	53.12	53.11	42.29
Float	10.98	1.62	6.80	1.43	1.15
Savage	37.30	9.49	21.5	8.95	7.08
Sieve	24.60	6.45	5.99	5.98	4.76
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Data compiled as of April 1986

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QuickBASIC 4.0

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QuickBASIC 4.0, the latest version of Microsoft's MS-DOS BASIC compiler, finally delivers on the promise of its name. Using an incremental precompiler and a threaded p-code interpreter, QuickBASIC 4.0 gives BASIC programmers the fast feedback of a BASIC interpreter without sacrificing execution speed in finished programs.

Still priced at $99, QuickBASIC 4.0's enhancements include support for multiple module programming and built-in debugging using Microsoft's CodeView debugger. QuickBASIC 4.0 can also link to routines written in Microsoft C, Pascal, FORTRAN, and Macro Assembler.

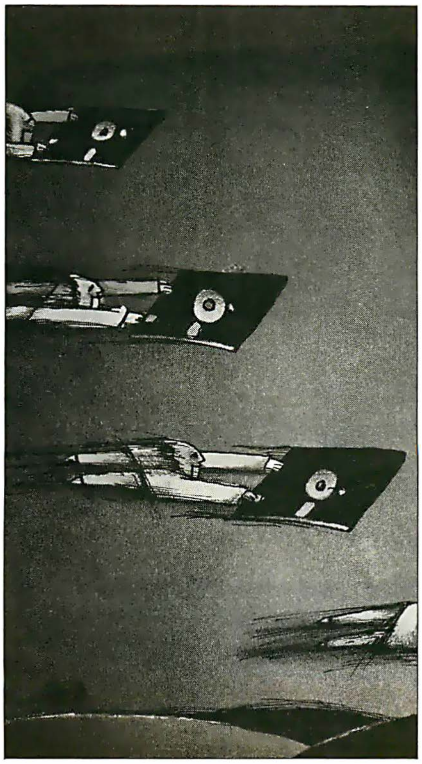
Instant Programming

With a user interface similar to earlier versions of QuickBASIC—and based on the Windows model—QuickBASIC 4.0 will be immediately familiar to users of previous versions. The integrated editor now supports WordStar commands for additional functionality (which also makes it friendlier to even longtime hackers.) The menu bar at the top of the editor's opening screen window sprouts pull-down menus offering you all the environment's file, edit, search, view, debug, and running options.

The first line of program code you enter, however, reveals an immediate difference in this environment. As soon as you touch the Enter key, QuickBASIC 4.0 precompiles the entered code and performs an immediate syntax check. If you've made a syntax or typing error, you get an error message and must correct the mistake. The precompiler checks each line of code as you enter it. When you finish entering code, your program will be syntactically correct.

But many of us like to test code as we write it, especially if we learned to program in an interpreted language. QuickBASIC 4.0 lets you run code fragments at any time. You merely select Start (or Alt-F5) from the Run menu and your code executes immediately, with no compile delay. The absence of the compile delay displays the major innovation in QuickBASIC 4.0—the threaded p-code interpreter (see the text box "The Threaded P-code Interpreter" on page 114 for an explanation of this technology). QuickBASIC 4.0 does not actually compile a program in memory. The compiler emits native-code executable files to disk only when you choose the Make .EXE option from the Run menu.

BYTE's First Impressions offer you an early look at products that are not yet in final form. In this case, the author had access to a late beta version of QuickBASIC 4.0. If interest warrants, BYTE will formally review this product when a final production version is available.



So, what you actually get with QuickBASIC 4.0 is an interpreter *and* a compiler seamlessly connected into the instant environment. The environment even features an Immediate Mode window, where you can execute individual code fragments without adding them to your program. This gives you a facility for testing your understanding of how keywords work or experimenting with code fragments.

The threaded p-code environment takes you one step further down the road of "quick" programming. You can execute code, interrupt the program, change the code or the values of variables, and resume execution with any statement. Since you do not have to restart the program from the beginning, you can test and fix small parts of code in an otherwise very large program.

Instant Debugging

Fixing code in QuickBASIC 4.0 is substantially enhanced by the addition of a subset of the CodeView debugger into the environment. The debug options include setting watchpoints that open a small window and display the value of a variable or expression as you single-step through code. They also include setting breakpoints that stop execution when code

continued

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Illustration by James Yang

reaches a specified location. You can trace both program flow and the values on the stack. You can also step through procedure and function calls.

A final enhancement to the programmer's workspace is a context-sensitive, on-line language reference. When you forget the exact syntax of a language keyword, you simply move the cursor to the keyword and enter Shift-F1 to open a window that displays the proper syntax. This help feature may not eliminate the need for manuals, but it will require you to use them less often.

A nice touch added by Microsoft—and a feature made possible by the p-code parser—is a "prettyprint" display of entered code. The prettyprinter puts BASIC keywords in capital letters and even corrects certain mistakes, like forgetting the ending quote symbol on the argument to a PRINT statement.

Listing 1: *The QuickBASIC 4.0 code to define a record.*

```
TYPE tile
  x1 AS SINGLE
  y1 AS SINGLE
  z1 AS SINGLE
  x2 AS SINGLE
  y2 AS SINGLE
  z2 AS SINGLE
  x3 AS SINGLE
  y3 AS SINGLE
  z3 AS SINGLE
  x4 AS SINGLE
  y4 AS SINGLE
  z4 AS SINGLE
  tcolor AS INTEGER

DIM t(0 TO MAX-1) AS tile
```

So how does it feel? I liked the QuickBASIC 4.0 environment immediately. Having the advantages of a "smart" interpreter makes programming fun again, and less restrictive than in the more rigid compiler environments. Then, turning your finished code into a fast-executing compiled program gives you great satisfaction with the entire process.

But what if you refuse to give up your favorite editor? Are you locked out of QuickBASIC 4.0's other enhancements (described below)? Fortunately, you can use QuickBASIC 4.0 as a stand-alone compiler, but doing so sacrifices the advantages of the "instant environment." To use QuickBASIC 4.0 as a stand-alone compiler, you invoke the BC.EXE and LINK.EXE programs.

Language Enhancements

While the new programmer's workspace is QuickBASIC 4.0's most important innovation, there are several other interesting new features in the program. Support for modular programming heads the list.

For a dozen years or more, the trend in professional programming has been to write code in small pieces, debug, test, and perfect the pieces, and then connect the pieces together into a working program. C, Modula-2, and Ada practically require the programmer to use this methodology.

QuickBASIC 4.0 supports modular programming in several ways. First, the environment forces programmers to think of subroutines (procedures) and functions (in QuickBASIC 4.0, subroutines that return values) as separate pieces. In fact, to write a subroutine or function, you must use the New SUB selection from the View menu. Selecting this option opens a new window into which you place your subroutine or function code. From that point on, your subroutine is a distinct unit. To view or edit the subroutine's code, you have to change to its window (you can display two windows simultaneously).

A program outliner shows you what subroutines and functions you've written during any one session (see photo 1). The subroutines and functions all belong to that session's module. A module is simply a collection of code stored under a single filename. The module carries the name you initially gave your program.

You can move subroutines and functions from one module to another using the Move option within the program outliner window.

Combining modules lets you build programs out of collections of smaller pieces. The size of a module is up to the programmer. QuickBASIC 4.0 permits multiple modules in memory, and you can even display and edit two modules on the same split screen.

When you save a program containing multiple modules (using the Save All option), each module is stored in a separate file on disk. QuickBASIC 4.0 builds a file with a .MAK extension that contains the names of every module in a given program. QuickBASIC 4.0 then uses this text file to load a program's modules into memory.

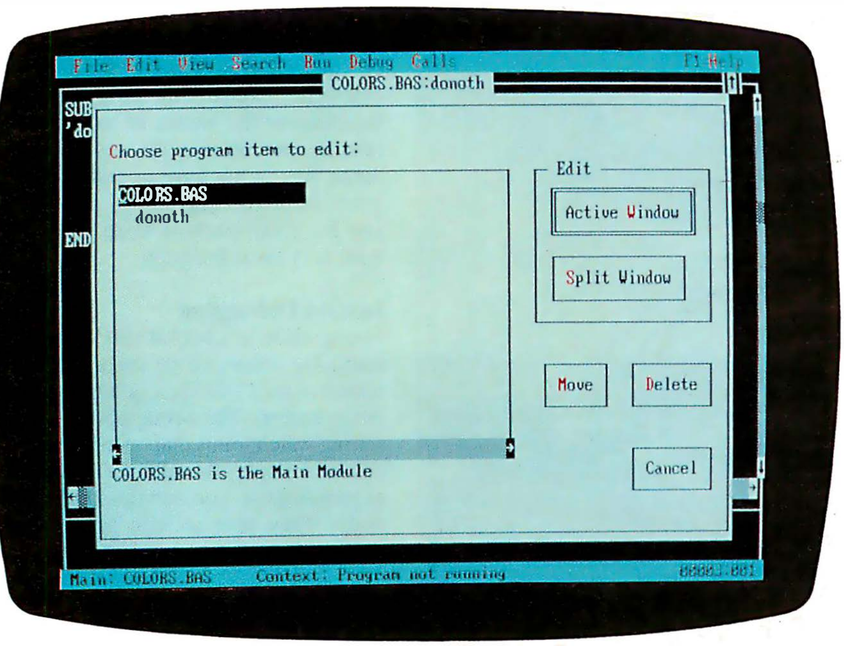


Photo 1: *The QuickBASIC 4.0 environment. The open window displays the program outliner with its list of module content.*

Other Enhancements

In addition to providing support for modular programming, QuickBASIC 4.0 provides a new record data type, true functions with support for recursion in subroutines and functions, binary file I/O, and the ability to call routines from other languages.

The TYPE declaration permits the building of record variables, analogous to Pascal records or C structures. Records streamline random file I/O and eliminate the need for the keywords FIELD, RSET, and LSET, although QuickBASIC 4.0 still supports them for downward compatibility with previous versions of BASIC. Listing 1 shows a sample QuickBASIC 4.0 record.

While QuickBASIC 4.0 still supports DEF FN, the language will now support true functions, subroutines that return values. These functions are created just like subroutines. They can contain local

continued



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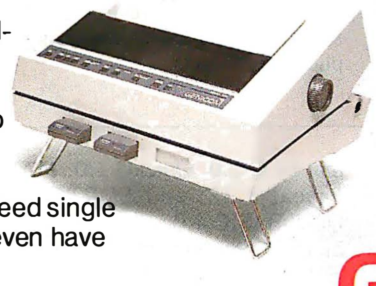
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The Threaded P-code Interpreter

Two key ideas make QuickBASIC 4.0's threaded p-code interpreter workable: precompilation of BASIC source code lines into code that you can execute but still display and edit at the source level, and an efficient way to run this code.

Here's how QuickBASIC 4.0 uses these ideas:

First, QuickBASIC 4.0 precompiles each line of BASIC source code into a form that is 90 percent executable machine code, housekeeping code being the remaining 10 percent of the precompiled code. This code is called Parsed in the Microsoft hierarchy. Parsed code can be edited but contains no symbol information about the program's variables.

At this point in the program creation process, you can run the entered program. When you invoke the Start option, the interpreter changes the state of the code to Symbolic by adding a symbol table for variables. Immediately upon completion of the change to Symbolic code, QuickBASIC 4.0 changes the code state again, this time to what Microsoft calls the Threaded state. This state change adds type-checking code, binds procedure calls and control structures to actual memory locations, links COMMON data, and generates code and addresses for executors, the actual machine code fragments that perform operations like PRINT or * (multiply).

Now, QuickBASIC 4.0 can execute the code by jumping from executor address to executor address. The p-code interpreter consists of two lines of assembly language code:

```
LODSW ES

JMP AX
```

These two lines are appended to each BASIC operation's machine code fragment during the Threaded state change.

The interpreter code does just two things: First, `LODSW ES` simply loads the microprocessor's AX register with the address of the next executor in the code; `JMP AX` merely jumps to the address in AX, the next executor, and executes its code, whereupon it encounters another `LODSW ES, JMP AX` instruction pair that sends it on to another executor. In this way, the code fragments are threaded together, executing in a sequence determined by how they were entered and parsed.

The threaded p-code interpreter actually becomes part of the executing program. Because the interpreted execution of the program is part of the program, you can stop a program in the middle of its execution, change parts of the code, and then resume execution. QuickBASIC 4.0 recompiles only the executor code that you changed and alters only the symbol table information affected by your changes.

The process of converting code from Parsed to Symbolic to Threaded happens at the rate of 60,000 lines per minute. When you stop and alter a running program, QuickBASIC 4.0 has to change the program's state from Threaded back to Symbolic to let the editor take over the microprocessor. This process happens at a rate of 150,000 lines per minute.

When you finally complete and debug your program, you can save it to disk as an executable file using QuickBASIC 4.0's Make .EXE option. Here, QuickBASIC 4.0 acts like a normal compiler. All the interpreter operation codes are discarded, and the compiler produces just executable machine code and symbol information.

The interpreter technology in QuickBASIC 4.0 is likely to appear in other products, according to a Microsoft spokesman, including language and application products.

---

variables and can be recursive (as can QuickBASIC 4.0 subroutines).

Binary file I/O allows you to `OPEN` binary files, `PUT` and `GET` at the byte level, and the new keyword `SEEK` provides direct access to any part of a file.

QuickBASIC 4.0 can call linked routines written and compiled to .OBJ format by C 5.0, QuickC 1.0, MASM 5.0, Pascal 3.32, and FORTRAN 4.01. QuickBASIC 4.0 uses the `DECLARE` statement to identify routines that it will later call. The keyword `CDCECL` is used when calling routines that use the C-language calling conventions, and `ALIAS` is used when calling C routines with names longer than eight characters.

To call FORTRAN or Pascal routines, you use the `FORTRAN` and `PASCAL` keywords. `BYVAL` allows the passing of parameters by value (necessary for C), and `SEG` lets you declare a far reference parameter.

Miscellaneous changes to QuickBASIC 4.0 include the addition of long (32-bit) integers to speed calculations involving large numbers; array indexes with variable, user-definable lower bounds, permitting declarations like `DIM` Date(1900,2000); `SELECT CASE`, block `IF...THEN...ELSE`, and `DO...LOOP` constructs; and the case-conversion functions `UCASE$` and `LCASE$`.

Judgment Calls

There are many things to like about QuickBASIC 4.0. The program senses the presence of an 80x87 math coprocessor and uses it automatically. In the absence of a coprocessor, QuickBASIC 4.0 emulates the IEEE-754 math standard in software, with a consequent slowdown in execution speed. You can still use your old data files containing numbers stored in Microsoft binary format (MBF) by compiling programs with the /mbf switch. Abandonment of the MBF for numerics may spur sales of math coprocessors, however.

QuickBASIC 4.0 lets you build Quick-Libraries that you can use to store different kinds of modules and routines that you have written in QuickBASIC 4.0 or another Microsoft language. Quick-Libraries exist in p-code format, and only QuickBASIC 4.0 can read and understand them. They can be shared among other QuickBASIC 4.0 users.

The principal advantage of Quick-Libraries is that you can call and run them from within QuickBASIC 4.0. Standard libraries, those that use the .LIB extension, can only be used by Make .EXE to make an executable file (.LIB libraries can also contain non-BASIC routines).

My tests of compile speeds showed QuickBASIC 4.0 to be very fast. Execution of programs was slow, but Microsoft promises minimum performance levels equal to QuickBASIC 3.0 in the final release version of QuickBASIC 4.0. We plan follow-up tests to this article to verify those claims. Microsoft says it has added the code optimizations performed by Microsoft C 4.0 to QuickBASIC 4.0, adding to the speed and compactness of QuickBASIC 4.0's code.

QuickBASIC 4.0 is definitely going to get me back into BASIC programming again. I'm sure I'll find little things that annoy me as I program more extensively, but my first impression of this package is that it is a winner. ■

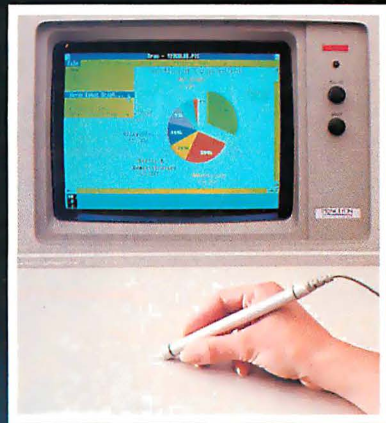
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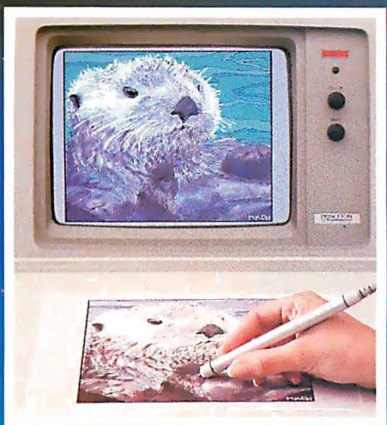
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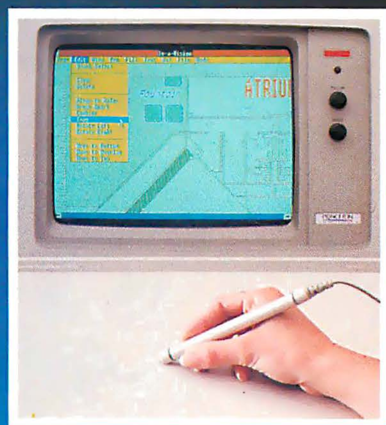
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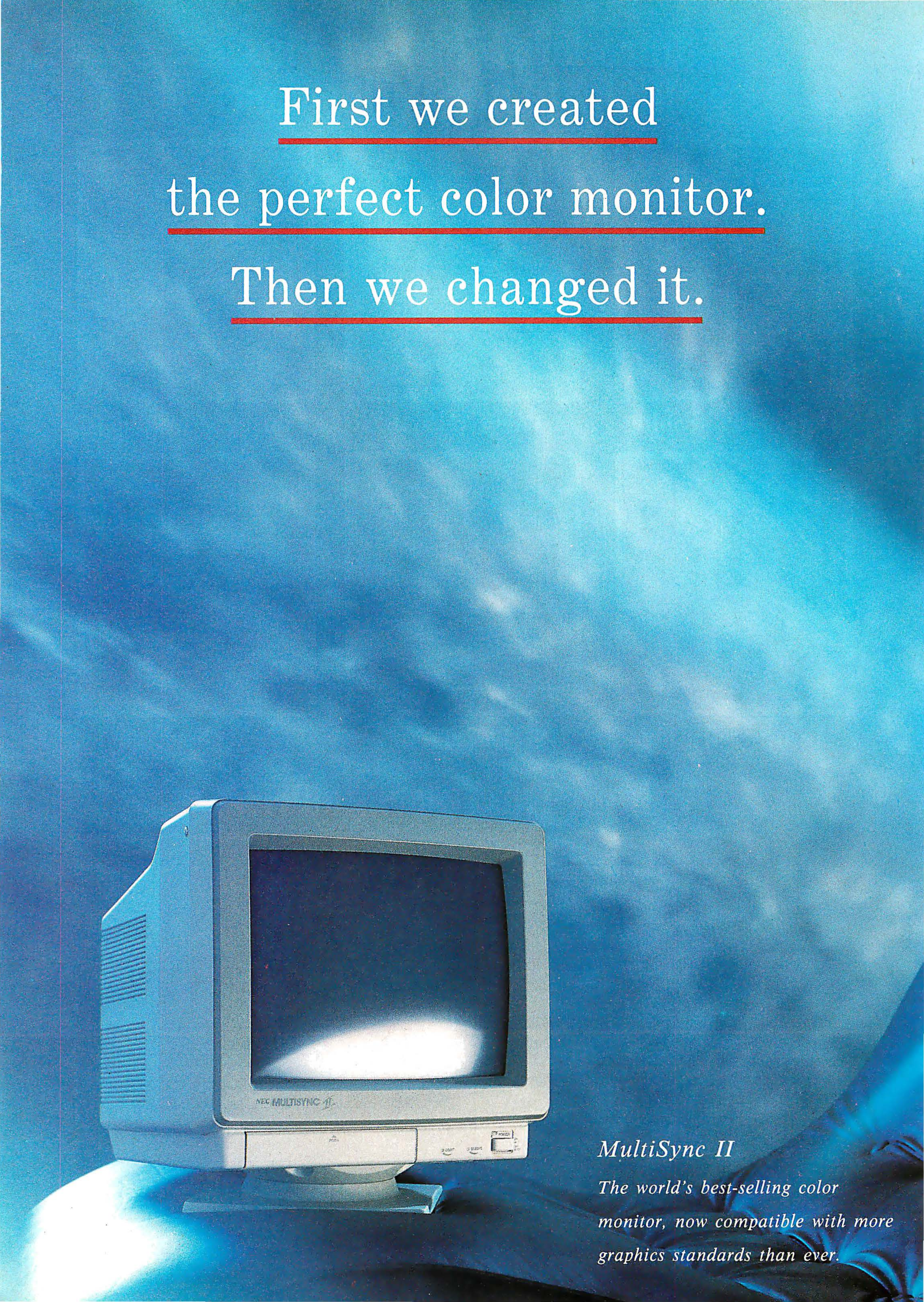
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Dial Modifier @ (Wait for quiet answer 'DATA BASE')	YES	YES	NO	YES
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Ezra Shapiro

Three New Spreadsheets

Microsoft's Windows Excel, Borland's Quattro, and WordPerfect's PlanPerfect challenge Lotus 1-2-3's dominance in statistical analysis

Will 1987 mark the start of a new battle for dominance in the world of MS-DOS spreadsheets? Or will Lotus 1-2-3 continue to be the program of choice for statistical analysis? Three new products from major manufacturers—Microsoft's Windows Excel, Borland International's Quattro, and WordPerfect's PlanPerfect—are set to take on the long-standing industry leader. The programs all advertise differing degrees of 1-2-3 compatibility, but each has unique strengths beyond the basic standard.

All three packages are unquestionably modern spreadsheets. They all offer expanded memory support; they all provide drivers for a wide range of printers, including PostScript devices; they all include a large assortment of functions for sophisticated financial analysis (including net present value, standard deviation, matrix inversion, linear regression, and so on); they all have a database mode and graphing capabilities; and they all have the ability to record keystrokes and play them back as user-defined macro commands. However, once you get beyond the common denominators, the programs are distinctive enough to appeal to separate audiences.

All three programs are excellent spreadsheets, and they're powerful enough to keep the most ambitious number cruncher happy. Windows Excel is the program most likely to elicit a "Wow! Look at that!" Quattro is the easiest upward path from Lotus 1-2-3. And PlanPerfect is a fitting complement to WordPerfect.

BYTE's "First Impressions" offer you an early look at products that are not yet in final form. In this case, while PlanPerfect was complete and available to the general public, the versions of Windows Excel and Quattro that were available to the author were both still in the late beta stage. However, during the week prior to BYTE's deadline, both Borland and Microsoft were readying revisions that ran 30 to 40 percent faster than the beta versions. If interest warrants, BYTE will formally review these products when the manufacturers ship the final production version.

Windows Excel

Microsoft's product, often referred to as "Win Excel," is perhaps the most striking of this trio of programs. Because of its dependence on the Microsoft Windows operating environment, it's the only one of the group that uses on-screen bit-mapped fonts throughout. And while a mouse isn't an absolute necessity, it would probably be a helpful addition that makes sense for scrolling around a large worksheet area.

The interface used is the familiar Windows/Macintosh/Xerox PARC black-on-white graphics screen with pull-down menus for commands. You move through the spreadsheet with the mouse, cursor keys, and scroll bars along the right and bottom edges of the display. You enter data and formulas at the top of the display; a status line at the lower left corner of the screen gives a longer explanation of each function.

You can link the loaded files to either resident or nonresident worksheets, so Excel lets you choose between fencing off a large spreadsheet or building smaller, separate units.

Excel 1.04 for the Macintosh has already received a lot of critical praise, and Win Excel is a direct descendant. But Win Excel is more than a simple port of the Mac product; Excel on the PC boasts a number of features that are brand new with this release. You can now view different typefaces on-screen, adjust row height (as well as column width) to accommodate formatting, and display cells in color (on a white background).

While Win Excel can read and write 1-2-3 worksheets, it's not completely compatible with 1-2-3. However, Microsoft has provided aids and workarounds to simplify the conversion process. For example, Excel recognizes the "=" sign as the command trigger that says you're about to enter a formula. If you slip and type "+" or "−" (the characters 1-2-3 uses to indicate formulas), Excel will automatically enter the "=" symbol instead. Lotus functions are prefaced with an "@" symbol; the "@" is unnecessary in Win Excel, but it will be accepted with no problem.

The keyboard commands that shortcut the pull-down menus with Control, Alt, and function-key sequences are not the ones used on the Macintosh; instead, Win Excel uses many of the Lotus commands. The help system is also designed for the Lotus 1-2-3 user; if you're stuck at a point where you can remember a 1-2-3 command but can't figure out the Excel equivalent, you can select a `Lotus Help` feature from one of the pull-down menus. Excel asks you to enter the 1-2-3 command, then drops you into the appropriate section of the extensive on-line Excel documentation.

Macros and functions are a bit trickier. Lotus 1-2-3 stores macros in individual spreadsheet cells; Win Excel uses sepa-

continued

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rate macro worksheets that are linked to spreadsheet files. Microsoft distributes a Windows application for macro conversion that will make the necessary modifications and prompt you for required information, such as a name for each macro. Most "@" functions translate directly between the two spreadsheets, but a number behave differently. Microsoft documents all the anomalies, but careful editing is still a good idea.

Win Excel will be distributed with the Windows run-time environment, which allows you to run the spreadsheet and the macro-conversion utility as stand-alone applications. If you want to have other applications on-screen at the same time, you'll need a copy of Windows 2.0, which will be available either as a retail product or bundled with your hardware.

Windows, unfortunately, is the spreadsheet's biggest liability as well as its greatest asset. Excel, like most of Microsoft's Windows applications, is written in C, and it's a large program, requiring a full 640K bytes of RAM. Although you can run Win Excel on an 8088-based computer equipped with a CGA, performance is slow. Microsoft strongly recommends that you use at least an AT with a hard disk drive and an EGA video card. Although the software was not finished enough for benchmark speed tests, I have no doubt it will prove to be the slowest of the three spreadsheets, at least for operations that involve screen handling.

The most interesting new feature is Win Excel's programmable menu system. You can look at the product as an application-development kit. You can create your own menus (on macro worksheets) and reassign keyboard shortcuts to your entries, and you can create dialog boxes that pop up on the screen with instructions or warning messages.

A limited form of multitasking lets you continue editing your Win Excel worksheet during recalculation. A small box in the upper left corner of the screen tracks the progress of the recalculation.

Quattro

Borland's entry in the spreadsheet sweepstakes is called Quattro: The Professional Spreadsheet (think "uno, dos, tres..."). It's the one product in this group most likely to attract die-hard fans of Lotus 1-2-3. The program is more a superset of 1-2-3 than a clone; Quattro can read and write both Lotus .WKS and .WK1 worksheets directly. (You can even use SQZ!, the utility from Turner Hall, to compress your files as you work.) There's no translation process to contend with; Quattro is fully compatible with all 1-2-3 commands, menus, functions, and macros. The Quattro interface uses pop-up menus in the right-hand third of the screen, rather than the Lotus menu

IN BRIEF

	Windows Excel	Quattro	PlanPerfect
Version	1.0 (beta copy)	(beta)	3.0 (shipping copy)
Price	$495	$195	$395
Scheduled ship date	October 1987	November 1987	July 1987
System requirements			
Memory	640K bytes	384K bytes	256K bytes (320K with graphics)
Drives	One floppy, one hard	Two floppies or one floppy, one hard	Two floppies or one floppy, one hard
CPU	80286	8088	8088
Lotus 1-2-3 compatibility			
Commands	No	Yes	No
Data	Yes	Yes	Yes
Functions	Most	All	Some
Macros	Some	All	None
Features			
Expanded memory	Yes	Yes	Yes
Sparse matrix	Yes	Yes	No
Minimal recalculation	Yes	Yes	No
Linked worksheets	Yes	No	Yes
Programmable user interface	Yes	Yes	No
On-screen fonts	Yes	No	No
Programmable colors	Yes	Yes	No
Mouse support	Yes	No	No
Edit while printing	No	No	Yes
Edit during recalculation	Yes	No	No
Coresident applications	Any Windows application via Windows 2.0	Specially written Quattro extensions	WordPerfect products via WordPerfect shell
Company address	Microsoft Corp. 16011 Northeast 36th Way P.O. Box 97017 Redmond, WA 98073 (206) 882-8080	Borland International 4585 Scotts Valley Dr. Scotts Valley, VS 95066 (408) 438-8400	WordPerfect Corp. 288 West Center St. Orem, UT 84057 (801) 225-5000

bar, but if you can use 1-2-3, you can use Quattro. Borland does offer a new file format, indicated with a .WKT extension, that allows for faster saving and loading of worksheets, but its use is optional.

The program occupies 384K bytes of RAM, and it's written in assembly language for speed. The minimum system configuration is a two-floppy 8088-based PC, so it will run on most existing MS-DOS machines. Quattro will sense the presence of a math coprocessor, a high-resolution video card, or expanded memory, and adjust its operations accordingly.

Quattro has a decidedly Borlandish look. The first thing you notice when you bring up the program is its extensive use of color. Row and column labels, the worksheet area, the cell cursor, the status and message lines, the pop-up menus—everything is highlighted in a different shade. You can, of course, reset the hues to your favorites, either temporarily or permanently. There's a practical side to this as well—you can set the colors for individual cell formats so you can have text in one shade, positive numbers in another, and negative numbers in a third.

Like Win Excel, Quattro's most impressive feature is its programmability. Not only can you change colors, but you can redesign all the menus and commands to suit your fancy. (The program comes with two such menu resources: One configures a Borland interface, the other renames the commands to their Lotus parallels.) Using a utility program called Menu Builder, it's possible to make minor modifications or to construct a whole new interface. The Menu Builder is distributed as a Quattro "extension"—the concept is similar to Lotus 1-2-3's add-in capability, but third-party products written for 1-2-3 will not work with Quattro. (The Menu Builder was not completed at the time this article was written.)

Other standout features include facilities for macro debugging, including temporary and permanent breakpoints for modification while executing a step-by-step trace, and enhanced charting capabilities—a wide selection of basic types, selectable fill patterns, editable labeling, and easy selection of graph series.

Finally, Quattro will keep a keystroke-by-keystroke transcript of your actions on the spreadsheet in a separate file. The transcript can be used either as an audit tool or as a recovery system if you accidentally destroy the original file.

PlanPerfect

PlanPerfect 3.0, the spreadsheet from WordPerfect Corp., is not an entirely new product. Earlier versions of the program were sold as MathPlan; the name was changed to bring it into line with the company's other packages.

Its primary appeal will be to users of WordPerfect, the word processor, rather than to 1-2-3 aficionados. Though PlanPerfect can read values from Lotus files directly, the commands are not written to be compatible. Many 1-2-3 functions have no direct equivalents in PlanPerfect; imported files require some editing. Macros are not translated at all—they come across merely as text cells.

However, the PlanPerfect interface and command set bear a strong family resemblance to those of other WordPerfect products, so the transition is relatively painless. Rather than using the / (slash) key to preface a command, PlanPerfect is largely controlled by function keys that trigger a line of options at the bottom of the screen—just like WordPerfect.

And PlanPerfect will operate under the WordPerfect shell, an integrating environment distributed as part of the WordPerfect Library. You can move from one application to another, cutting and pasting between them, without returning to the DOS level.

The shell keeps a portion of each loaded application resident in RAM, so switching back and forth is quick. Anyone who has attempted to build a business report out of WordPerfect documents and 1-2-3 spreadsheet files will appreciate the convenience.

As befitting a spreadsheet from a company known for its word-processing software, many of PlanPerfect's strongest features are those for handling text and output. You can easily swap text, numerical data, and character graphics files between WordPerfect and PlanPerfect, whether you're using the shell or not. You can attach text blocks, generated with a note editor that has simple word-processing capabilities, to any specific cell for user instruction or documentation.

PlanPerfect does not have a programmable interface, but a Forms mode lets you create data-entry forms and store worksheets for repeated use; the data-entry clerk cannot edit cells that have been intentionally protected or locked.

Other features include print queuing, background printing while editing, automatic backup at timed intervals, and a macro recorder identical to WordPerfect's.

Though PlanPerfect lacks the sparse matrix design and "minimal recalculation" algorithm of Quattro and Win Excel, it's fast enough to run on an 8088 computer. A WordPerfect employee commented that these features would be added in a future version. Also, PlanPerfect's expanded memory support goes up to a whopping 8 megabytes, so you don't have to be concerned about constructing large models. You can link worksheets, too, and thus break a huge model into easily handled smaller chunks.

Beyond the common denominators, the programs are distinctive enough to appeal to separate audiences.

Brief Impressions

Windows Excel was the most spectacular of the programs, but it was also the most complex to learn; familiarity with either the Macintosh or other Windows applications is a big help. Once you get up and running, though, it's a delightful product, certainly as powerful as anything else out there, and it will easily attract the same kind of fervent following its cousin has on the Mac. Its size was a drawback—without expanded memory, Excel can handle a spreadsheet of only about 150K bytes to 170K bytes. But linking to nonresident worksheets goes a long way toward making up for the memory limitations.

Quattro was by far the simplest program to use, and also the friendliest. The rewritten Borland menus clarify much of the Lotus jargon, and operations that appear difficult in 1-2-3 seem much easier in Quattro. As mentioned above, it's a perfect choice for either the novice spreadsheet user or for someone who has mastered every arcane twist of 1-2-3.

PlanPerfect is further from the Lotus paradigm than the other two spreadsheets, but it does have all the necessary features. It's not a strong contender if you already have your data set up for 1-2-3, but if your decision is not restricted by a large stock of preexisting worksheets, and you like WordPerfect, it's worth considering. It's the smallest of the programs, and it addresses the largest amount of expanded memory, so it's fine for complex models.

The biggest question raised by these programs is the issue of application development. Will the programmable interfaces of Win Excel and Quattro lead to the same sort of industry spawned by database languages? Time will tell. ■

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Gregg Williams

MultiFinder for the Macintosh

MultiFinder trades off limited multitasking for complete compatibility with existing programs

MultiFinder, Apple's new multitasking operating system for its Macintosh computers (see photo 1), is yet another step in the growth of the computer that introduced the increasingly popular icon/window/mouse/pull-down-menu user interface. It adds both convenience (quick switching among applications in simultaneously visible windows) and productivity (background LaserWriter printing and limited multitasking) to the daily use of the Macintosh, yet it promises to work with almost all existing applications. Apple reports that this is the only the first version of MultiFinder, and later versions will bring more and more multitasking capabilities to the Macintosh, while maintaining compatibility with most existing applications.

Apple plans to bundle MultiFinder free with new Macintoshes, with current users getting it for $49 or less. (However, as of mid-September, it was still testing the program.) This action supports Apple's claim that MultiFinder is an integral part of the basic Macintosh system, to be built upon by future products. But don't put your wallet back just yet—older Macintoshes will have to get the 128K-byte ROM upgrade, and you'll need extra memory and a hard disk to *really* use MultiFinder to its best advantage.

What it Is—and Isn't

MultiFinder works with *any* Macintosh Plus, Mac SE, or Mac II machine (upgraded machines must have the 128K-byte system ROMs). While it can run on a 1-megabyte machine, extra memory is almost essential for MultiFinder to be really useful. When you are running MultiFinder and click on an application, it opens as usual, but you can also access the windows of other opened applications and the Finder.

You can continue to open applications (up to 30, Apple says) by simply clicking on their icons in the Finder, and you can move between applications by clicking in the appropriate window. Applications also have menu items in the "Apple" menu, underneath the menu items for all the desk accessories. If you can't get to an application's window, you can still make it active by selecting its menu item or by double-clicking on its dimmed icon on the desktop.

MultiFinder resides in your System Folder, along with the Finder, but doesn't replace it—you can still run the traditional one-application-open-at-a-time Finder if you prefer. According t "[MultiFinder] is the operating code that makes multitasking it's actually an addition to the System file."

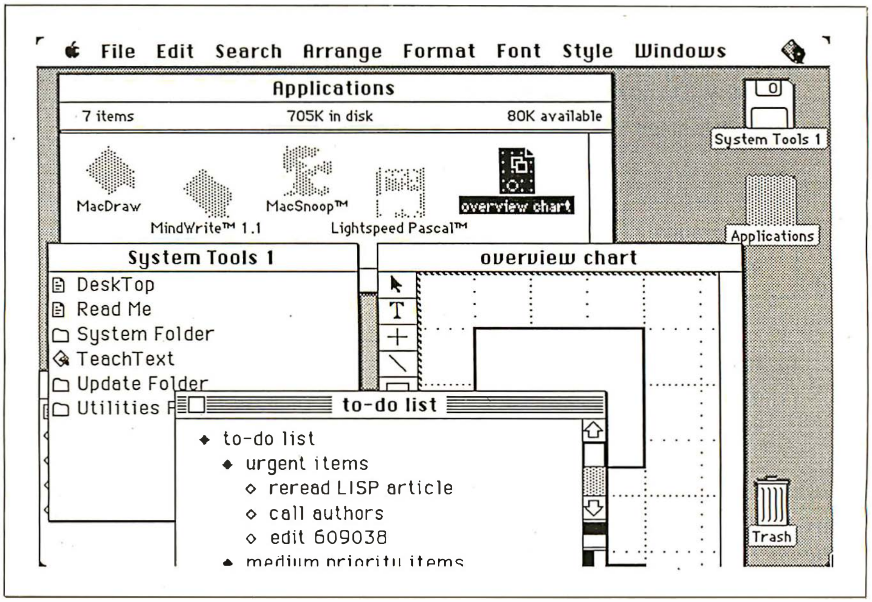
MultiFinder brings several new files with it. Backgrounder and PrintMaster permit the background printing of Laser-

continued

BYTE's "First Impressions" offer you an early look at products that are not yet in final form. In this case, the author based his report on experiences with a late beta version of MultiFinder, lengthy talks with Apple programmers, and Apple documents. If interest warrants, BYTE will formally review this product at a later date.

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Photo 1: *MultiFinder at work.*



Writer files, while a file called DA Handler gives desk accessories (DAs) new life: Since MultiFinder is multitasking, DAs don't have to deactivate an application to run. This means that DAs stay active until you shut them down, and, in particular, they don't disappear when you move from application to application.

It is important to understand the way in which MultiFinder's multitasking is limited. Existing applications are dormant when they are in the background—their windows are open but deselected, and they come back to life when you click in their windows again. However, new applications written for MultiFinder can perform certain designated work—but not the entirety of their normal behavior—while they are in the background.

Actually, this situation may change as programmers get better at writing backgrounding applications. A background application—one that is open but inactive—has full access to the Toolbox routines and operating-system services, but it *doesn't* see any events (such as mouse movement and disk insertion, for example) because they are intended for the foreground application. So it's possible to write an application that will do many of its normal operations even in background. For example, you might be able to start a spreadsheet recalculation while you're in the foreground, then have it finish and display its results in the background while you do some other work.

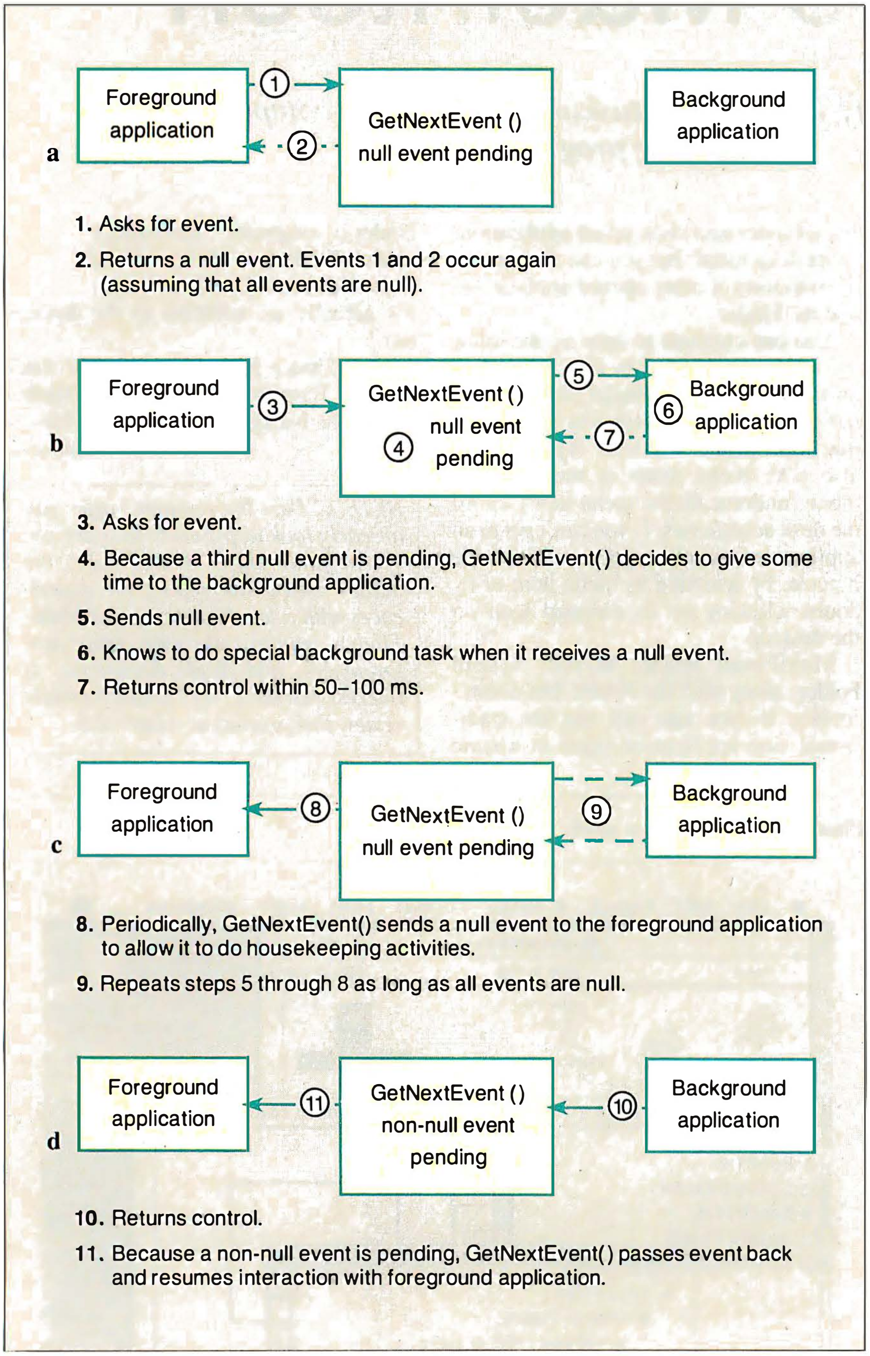


Figure 1: *How MultiFinder works with existing Macintosh software. Basically, MultiFinder steals time from applications when they would otherwise be idle. See the text for details.*

MultiFinder: an Overview

Macintosh applications have always been *event-driven;* that is, the program watches for an event (which can be anything from a key press to a mouse movement), decides what kind of event it is, processes the event, then repeats this sequence in a loop. All Mac programmers are very familiar with a routine called `GetNextEvent`, which returns the next event. (`GetNextEvent` is usually preceded by `SystemTask`, which must also be called periodically to service desk accessories.)

`GetNextEvent` is the key to understanding how MultiFinder works. Most of an application's time is spent waiting for the user to do something—press a key, select a menu item, and so on. During this time, `GetNextEvent` returns with a *null event,* indicating that no events have occurred. Since a user leaves (to the Mac's frame of reference) large intervals of time essentially unused, this wasted time is an obvious candidate to be "stolen" from the main program (the *foreground application*) and given to another program (the *background application*) that can use it. If multiple applications have background work they can do, `GetNextEvent` gives a different application control, in round-robin fashion, each time it is called.

We now know *where* MultiFinder gets the time from the foreground application to execute a background application—but *how* does it do so? Again, `GetNextEvent` is the key. MultiFinder uses an enhanced version of `GetNextEvent` that works as follows (see figure 1): When it sees more than one null event in a row, it transfers control to a background application, trusting that it will return control in a reasonable period of time.

As long as `GetNextEvent` continues to receive null events, it will continue to return control to the background application, pausing periodically to send the foreground application a null event (many applications use null events to do things like maintain the shape and blink rate of the cursor and do memory garbage collection). When a non-null event occurs, `GetNextEvent` switches back to dealing exclusively with the foreground applica-

tion. Note that this scheme works even with *existing, unchanged* Macintosh applications.

Background applications respond to a null event by doing some low-priority work, called *background tasks.* Its code is written so that it executes `GetNextEvent` in, at most, 50 to 100 milliseconds, thus giving MultiFinder the opportunity to transfer control back to the foreground application. This restriction is critical to preserving the responsive, no-waiting feel of the foreground application. The converse is not true: The foreground application can keep control as long as it likes (within limits); this means that background tasks cannot know how often they will get processor time.

Another limitation that MultiFinder has to meet is that the interrupt handler of the file system doesn't keep track of which task started certain file operations. Because of this, MultiFinder checks a flag in the file-system globals area and waits for an application to finish all active file-system requests before it takes control.

As shown above, MultiFinder uses `GetNextEvent` as a switching point to steal otherwise wasted time from the oldest type of Macintosh application. However, MultiFinder can steal time more efficiently and transfer between applications faster if the applications are properly written. Before we can fully understand how this happens, we first need to look at how applications deal with Apple's Switcher program.

MultiFinder and Switcher-Friendly Applications

Switcher, which was created in 1985 by Andy Hertzfeld, allows you to partition the memory of the Macintosh into separate compartments, each of which contains an application and thinks it has a whole Macintosh to itself. The program's name comes from its ability to keep several programs (and their screens) ready and switch quickly among them; one is active while the others lie dormant and invisible.

One of the obvious uses for Switcher is to switch rapidly between, for example, a painting program and a word-processing program, cutting data from one and pasting it to the other. However, a problem arises here: Many applications use a "private scrap," an area used to store the data that is being cut, copied, or pasted within that application. Data in the private scrap may be in a format that other applications don't understand. To maintain consistency with the desk scrap (also called the Clipboard), such applications copy and convert the desk scrap to the private scrap

continued

A Programming Test with MultiFinder

Tom Thompson

We were able to experiment with applications' backward compatibility with MultiFinder by using a test application that I had written for the Mac II. The results prove that, by changing a single bit in the `SIZE` ID = −1 resource, you can make an already-working program multitask correctly under MultiFinder. [Editor's note: *The program, which also works on the Mac Plus and the Mac SE with their monochrome monitors, is available in the Macintosh section of the Listings conference on BIX. The file, named "colrbkgd.pit," contains compressed versions of the source code, its associated RMaker resource text file, and an executable version of the program described here.*]

The application is a simple event loop that handles an expandable window, mouse clicks, desk accessories, and a `quit` program command, either from the keyboard or by menu selection. The application's null-event code draws randomly sized and placed colored boxes in the window. The application was compiled under Lightspeed C version 2.11, and I ran it under MultiFinder beta version 1.0b3 on a Macintosh II with 1 megabyte of memory.

The application behaved as you might expect with the current state of MultiFinder: As long as its window was the foreground task, the program drew its boxes continuously. However, the moment I either activated a desk accessory or clicked on another window, making its owner the foreground application, the color display stopped. The color-box application received a deactivate event when this context switch occurred, as indicated by the blanking of its grow-window icon.

However, the Apple programmers had told us that it was possible to make certain existing applications operate as background tasks simply by setting the `canBackground` bit in an application's `SIZE` ID = −1 resource. I checked this out with my test application. First, I made a copy of the application. Next, I used ResEdit to cut the `SIZE` ID = −1 resource from MacWrite 4.6 and paste it into the application. Finally, I opened the application's new `SIZE` resource and set the second undef bit from the bottom (the documentation had indicated that bit 12 was the `canBackground` bit), saved the file, and exited ResEdit.

The modified color-box application behaved as before when it was a foreground application, but it continued to draw colored boxes, even when placed in the background under MultiFinder. The display stopped when I performed operations in the foreground window (such as a drag to select text in an editor window), but the moment I completed the operation, MultiFinder would resume passing the null events to my application. Remember that the only reason it continued to work in the background was that drawing boxes was what it *normally* did in response to null events. If it had drawn boxes, say, in response to mouse clicks, the color-box application would have remained static when it was in the background.

This backgrounding capability occurred without my rewriting any code; in fact, the compiler I used doesn't even support the `WaitNextEvent()` call. This indicates that most of the aspects of MultiFinder will not intrude on an application's design. We'll have to wait and see how difficult it will be to add significant null-event background processing to applications, however.

This test shows two important things about MultiFinder: Where it is now, and where it is going. Currently, even with unmodified old Macintosh applications, you can have several applications open simultaneously, but only one—the foreground task—will be active. But in the future, as more and more applications add backgrounding capabilities, MultiFinder will start resembling a true multitasking environment, with several applications doing limited processing concurrently. Admittedly, background tasks will halt when there is a lot of activity in the foreground task, but one of the design goals of MultiFinder was to present the user with a responsive machine. This responsive nature, which is at the expense of the background tasks, seems to be a suitable compromise.

Tom Thompson is a technical editor at BYTE (One Phoenix Mill Lane, Peterborough, NH 03458).

Task Switching in MultiFinder

In this article, we saw how control passes from a foreground application to `GetNextEvent` or `WaitNextEvent`, then to a background application and back. But how exactly does this happen? The Macintosh under MultiFinder *isn't* a multitasking computer, with an interrupt-driven multitasking executive doling out slices of computer time to independent tasks. Rather, the foreground and background applications and `GetNextEvent` (or `WaitNextEvent`) are like amiable coroutines, each voluntarily handing control back and forth.

Still, what are the details of switching between applications? As expected, the software must save the state of the 68000 or 68020 processor (i.e., the registers and program counter). It must also save the Toolbox globals area (variables used by the Macintosh Toolbox system code that help define the application's environment) in low memory.

In addition, MultiFinder watches applications as they load themselves in. If they modify any entries in the trap dispatch table (which is often done to correct or enhance existing Toolbox routines), MultiFinder notes and saves these changes.

MultiFinder saves all this necessary information for every application currently open in PCBs (process control blocks), which are located in memory just under the applications and just above the free memory and the system heap in the Macintosh's address space.

when they begin, and reverse the process when they exit.

The problem with Switcher is that if it interrupts and suspends a program with a private scrap in the *middle* of its execution, the desk scrap will not contain the contents of the most recent cut or copy operation. To handle this, Switcher needs to perform a *scrap coercion*, which converts between the private scrap and the desk scrap in the appropriate direction.

Not being able to cut and paste between some applications would have severely limited Switcher's usefulness. Fortunately, Hertzfeld came up with a convoluted but brilliant solution that has been described as "an intricate charade." This charade hinges on the fact that all applications *must* be able to exchange data with desk accessories via the desk scrap using the universally understood `TEXT` and `PICT` data types. The solution was for Switcher to feed the application fake events that caused the application to call an imaginary desk accessory and paste to or copy from it (as the situation required). This caused the application to convert between its private and public scrap, thus enabling it to be switched in or out correctly.

It turns out that about 75 percent of the time needed to switch between applications is consumed by the desk-accessory charade. Certainly, this scheme could be used by new Macintosh applications, but Hertzfeld wanted to devise some way for them to be "Switcher-friendly"—that is, to interact with Switcher faster and more gracefully.

Hertzfeld defined two new events, *suspend* and *resume*, and specified how an application could be marked as knowing how to react to them (more on that later). Such an application responds to a suspend event by copying and converting its private scrap to the desk scrap itself, then calling `GetNextEvent` (at which time Switcher will take over and make another application active). When it gets a resume event, it copies and converts the desk scrap back to its own private scrap before it resumes executing. So, when Switcher sees that an application can handle suspend and resume events, it sends those events to it, knowing that the application will automatically coerce the scrap correctly (and much faster than the desk-accessory charade would have done it).

Since this mechanism already exists in most Macintosh applications, the designers of MultiFinder decided to recognize Switcher-friendly applications and send them suspend and resume events, thus allowing faster switching among them than would have been possible using the desk-accessory charade.

MultiFinder and "JugglerAware" Applications

Although MultiFinder works as efficiently as it can with existing pre- and post-Switcher Macintosh applications, it turns out there's a way to make MultiFinder interact even faster with newly written applications that are, as Apple puts it, "JugglerAware." (MultiFinder's internal name was "Juggler," so many of the data structures associated with it have the word "Juggler" somewhere in them. Any application that is JugglerAware should also be Switcher-friendly.)

A bit of history: Back when the Macintosh had only 128K bytes of memory, it needed every spare byte it could get. To make extra room just before giving control to a desk accessory, applications often threw away code segments loaded from disk to free up some memory; then, when the application regained control, it had to reload the code segment. Obviously, such a disk access slowed things down perceptibly.

An application running under MultiFinder is in a very different situation. First, there's enough room to keep code resources in memory. Second, doing so will save the time of a disk access when the user reactivates the application. So a JugglerAware application saves time by not throwing out code resources that a few of the older pre-MultiFinder applications (MacWrite, for example) would have.

Actually, another mechanism saves the JugglerAware application a bit more time *and* implements the strategy mentioned above. Under Switcher, a suspend event would take control away from the current application but leave it activated—its menu bar would be shaded, and its scroll bars would be filled in. Under MultiFinder, though, an application to be suspended must also be deactivated because it shares the screen with other application windows, only one of which can be active at a time. So, under MultiFinder, a suspend event *must* be followed by a deactivate event, preferably one that would somehow not throw out code resources.

This presents MultiFinder with another way to save time. It assumes that an application marked JugglerAware will, when it is suspended, also carry out the essential parts of a deactivate event. This saves some time, in that the application does not have to wait for a deactivate event, then decode it and act upon it. Also note that it carries out the *essential* parts of a deactivate event—that is, the visual changes that show the window is inactive, but not the time-wasting unloading of code segments.

MultiFinder and WaitNextEvent

Under MultiFinder, the Event Manager contains both the enhanced `GetNextEvent` discussed earlier and a new Toolbox call named `WaitNextEvent`, which allows the calling application to surrender otherwise wasted time to the background process more efficiently. (By the way, both calls now include the work formerly done by `SystemTask`.) Apple recommends that all new applications and updates to old applications use it in place of `GetNextEvent`. (However, new applications must be prepared to execute `GetNextEvent` if `WaitNextEvent` finds

continued

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itself running under Finder or Finder/Switcher.)

`WaitNextEvent` is called as follows:

```
Function WaitNextEvent
  (   mask       : INTEGER;
  VAR theEvent   : EventRecord;
      sleep      : LongInt;
      mouseRgn   : RgnHandle)
         :BOOLEAN;
```

Like `GetNextEvent`, it contains a mask field that tells the routine what events to ignore, and an event field that returns the value of the next event to be processed. The two remaining fields allow it to interact more efficiently with MultiFinder.

When you use `WaitNextEvent` in an application, you should know approximately how long MultiFinder can afford to take control away from your application. (The idea is that your guess will often be longer than the maximum value that MultiFinder would use for an application it knows nothing about.) You specify this number in 1/60 second *ticks* in the `sleep` parameter.

Table 1: *How Macintosh applications work with different Macintosh operating environments. In addition, the Finder-plus-Switcher and MultiFinder environments make use of built-in optimizations when running applications that recognize them.*

	Old applications	Switcher-friendly applications	MultiFinder applications
Finder	Work normally	Work normally	Work normally
Finder plus Switcher	A: must use desk-accessory charade to convert scrap	B: work faster because they respond to suspend/resume events by converting their scraps efficiently	Same as B
MultiFinder	Same as A; also, C: `GetNextEvent` steals time for background tasks after successive null events.	Same as B and C	* `WaitNextEvent` steals time more efficiently; * Applications do automatic activate/deactivate after resume/suspend; * Applications don't restore/discard code resources as part of activate/deactivate action.

Table 2: *The* `SIZE` *ID = −1 resource. MultiFinder examines the data in this resource to determine how best to interact with it.*

Type of data	Bit(s)	Use
Flag word	15	Unused by MultiFinder
	14	0 = application does not understand suspend and resume events 1 = application understands suspend and resume events
	13	Unused by MultiFinder
	12	0 = application cannot do backgrounding 1 = application can do backgrounding
	11	0 = application is not JugglerAware (MultiFinder-compatible) 1 = application is JugglerAware
	0-10	Unused by MultiFinder
Unsigned longint	0-31	Amount of memory to be reserved by application
Unsigned longint	0-31	Unused by MultiFinder

The value you specify is the maximum time MultiFinder will give to background applications before coming back to the foreground application, *given that nothing but null events are occurring*. If a non-null, unmasked event occurs, MultiFinder returns control to the foreground application as soon as the background application returns control to it. For example, the word processor I'm using blinks the cursor a little less than once per second. It could use `WaitNextEvent` with a `sleep` value of around 30, meaning that, even when it is doing nothing, `WaitNextEvent` will return its control with a null event, at worse, twice per second. If you give `sleep` a zero value, it behaves like `GetNextEvent`.

In some applications, the cursor does not blink, and the only thing an idle application has to worry about is the possibility that the user will move the cursor to a location that will necessitate a change in the cursor shape. The last parameter of `WaitNextEvent`, `mouseRgn`, helps this situation. It specifies a region inside which mouse movement does not cause an event to occur. So, by specifying the region in which the cursor stays the same, you can greatly lengthen the amount of time that MultiFinder can devote to background tasks. (System software checks for mouse movement and repositions the cursor at each clock tick—automatically and independently of the current application. This means that, by using `WaitNextEvent`, even considerable mouse/cursor movement will not "yank" control back to the foreground application in some situations.)

`WaitNextEvent` interacts with the foreground and background applications in much the same way as `GetNextEvent` does in figure 1, though a few things are different. `WaitNextEvent` doesn't wait for several null events to transfer control to a background application; it knows it can do so immediately. It also doesn't send a periodic null event back to the foreground application; the `sleep` parameter tells `WaitNextEvent` how long it can ignore the foreground application. It gives control to the background event until either `sleep` ticks pass or a non-null event occurs.

How MultiFinder Works: a Summary

We have three different kinds of applications (pre-Switcher, optimized for Switcher, and optimized for MultiFinder) and three different environments for them to run in (Finder, Finder plus Switcher, and MultiFinder). Not only do all applications run under all environments, but they also do so as efficiently as possible. Table 1 summarizes the possible application/

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environment combinations.

MultiFinder looks inside an application for a SIZE resource with ID = −1 to determine how to interact with it. Table 2 describes the fields. This resource includes the memory size to be reserved for the application and three MultiFinder flags. The MultiFinder SIZE ID = −1 resource is compatible with the one that Switcher-friendly applications use. In addition to the JugglerAware flag I have already talked about, there is also a background flag that indicates whether or not the application has a background task that it can do when it is inactive and receives a null event. The last flag indicates whether or not the application recognizes suspend and resume events.

Backgrounder and PrintMaster

One of the design goals of MultiFinder was to provide background printing support for documents printed on the LaserWriter (it does not support Imagewriter documents). MultiFinder does this with two programs. The first, Backgrounder, is a very small program, always active but invisible to the user. It continuously scans for the creation of a *spool file* (the disk file created when, with background printing enabled, you've sent a file to be printed on the LaserWriter). When it detects one, it launches PrintMaster, a larger program that does the actual background printing of the spool file. Apple uses this two-program approach to minimize the memory and processor time used to watch for spool files.

PrintMaster provides both information about and control of the list of documents waiting to be printed. You can make its window visible by double-clicking on its dimmed icon in the System Folder. In the PrintMaster window, you can see what's waiting to be printed, change the order of printing, cancel or suspend a print job, or set a specific time for a document to print. PrintMaster's window does not show itself unless you ask for it or it needs to notify or ask you about something.

Experiences Using MultiFinder

You need 2 megabytes of memory and a hard disk for MultiFinder to be really useful. I worked briefly with a late beta version of MultiFinder on a Mac Plus with two 800K-byte floppy disk drives (the minimum configuration needed) and found that I couldn't get more than one of my favorite three applications (Microsoft Word 3.0, Red Ryder 8.0, and MindWrite) open at once. I checked the "About MultiFinder..." menu item in the Apple menu (when MultiFinder is active) and found that, for example, the Red Ryder telecommunications program was

continued

MultiFinder Technical Notes

The following covers some rather technical topics related to MultiFinder; some of it will be of particular interest to software developers:

The Layer and Window Managers:
I have already talked about the changes to the Event Manager, an enhanced GetNextEvent and the new WaitNextEvent. MultiFinder also interacts heavily with both the Layer Manager and the Window Manager.

The Layer Manager is a new set of Toolbox routines added for MultiFinder support. With multiple applications on the screen (some with multiple windows per application), the Layer Manager arbitrates the applications' needs to draw to the shared screen. Applications will not use the Layer Manager directly except through the calls they make to the enhanced Window Manager, which uses the Layer Manager directly.

Background update events:
Background applications gain temporary control of the Macintosh when a user event, usually a window being dragged, uncovers part of a background window. The Layer Manager then causes the Event Manager to generate update events for that window. The next time GetNextEvent or WaitNextEvent executes, MultiFinder feeds the application its update events until it processes them. This means you should design your applications to respond immediately to update events instead of (as some applications do) deferring them for later processing.

Programming the virtual Macintosh:
As correct program operation becomes more and more a matter of application software getting work done by going through the proper channels (e.g., drawing to the screen through QuickDraw system routines instead of writing directly to screen memory), the Macintosh becomes less of an actual machine and more of an abstract or virtual machine that must be manipulated through supplied routines. (This also allows Apple to change the physical details of the machine and, by modifying the proper routines, ensure that older software will still run correctly.)

In many ways, current guidelines make the Macintosh less tolerant of unofficial shortcuts that are easier or faster to implement. MultiFinder's intricate interaction with the Event and Window Managers and the desk accessory menu means that applications should not try to do anything tricky with them. The frequent swapping of low memory means that applications should not read low-memory contents if at all possible, and certainly not try to change their values directly. Apple has a list of guidelines that spell out these limitations in detail.

The Philosophy and Future of MultiFinder

MultiFinder was designed from the ground up by Erich Ringewald, Phil Goldman, Patrick Ross, Bayles Holt, Scott Douglass, and Jay Patel, all from Apple. It represents Apple's first serious redesign of the Finder operating system, combining backward compatibility with an underlying design that lays the groundwork for a long line of enhancements to come.

Apple promises that this and the next release of MultiFinder will work on any Macintosh and "may or may not use" the 68851 MMU (memory-management unit) that is available for the Mac II but not the Plus nor the SE. After that, only time will tell. "Some number of steps downstream," one programmer said, "[MultiFinder] will only work on the MMU. It may not be the third; it may not be the fourth—we don't know how many steps that'll be. We're going to do it as smoothly as possible. Apple's strategy is 'Let's protect our users.' "

MultiFinder's cooperative multitasking contrasts sharply to traditional multitasking operating systems, which keep control of the computer and dole out slices of time to multiple programs that are unaware of each other. "The way we see it," one Apple programmer said, "the OS should be driven by the applications—it should deliver services and otherwise stay out of the way."

using 384K bytes of memory.

Under MultiFinder, the "Get Info" box of an application shows the "suggested memory size" (which you can't change) and the "application memory size" (which you can). By changing the latter to fairly minimal values, I was able to get both Word and Red Ryder running on a 1-megabyte Macintosh. (Word 3.0 and MindWrite are fairly large applications; if your taste runs to smaller programs, you might be able to get three applications running in a 1-megabyte Mac.)

MultiFinder takes up over half of an 800K-byte disk—even when you discard extraneous files—leaving you a maximum of 1200K bytes free on a two-floppy system for at least two applications and your data files. If, like me, you are committed to saving your current file on one disk and its backup on a different one, you'll have to either design your disk directories carefully or swap disks to make a backup. A hard disk can hold both MultiFinder and all your applications, leaving your floppy disk drive(s) free for data files. You'll be in better shape if you have a hard disk.

Final Thoughts

Comparisons to IBM's OS/2 operating system are irresistible: MultiFinder should be available by the time you read this (OS/2 with its graphic interface won't be ready until mid-1988), it works with existing applications (OS/2 doesn't), and it is free with new Macs and $49 for existing users (OS/2 costs $325 and up). MultiFinder's only clear shortcoming is that, according to IBM, all OS/2 applications will do true multitasking; for now, although multiple Mac applications can be open, only new ones written for MultiFinder can actually do some limited work when they are in the background. This limitation is actually the price of full backward compatibility: If Apple had forced *all* MultiFinder applications to be newly written, then MultiFinder—like OS/2—could easily have included full multitasking.

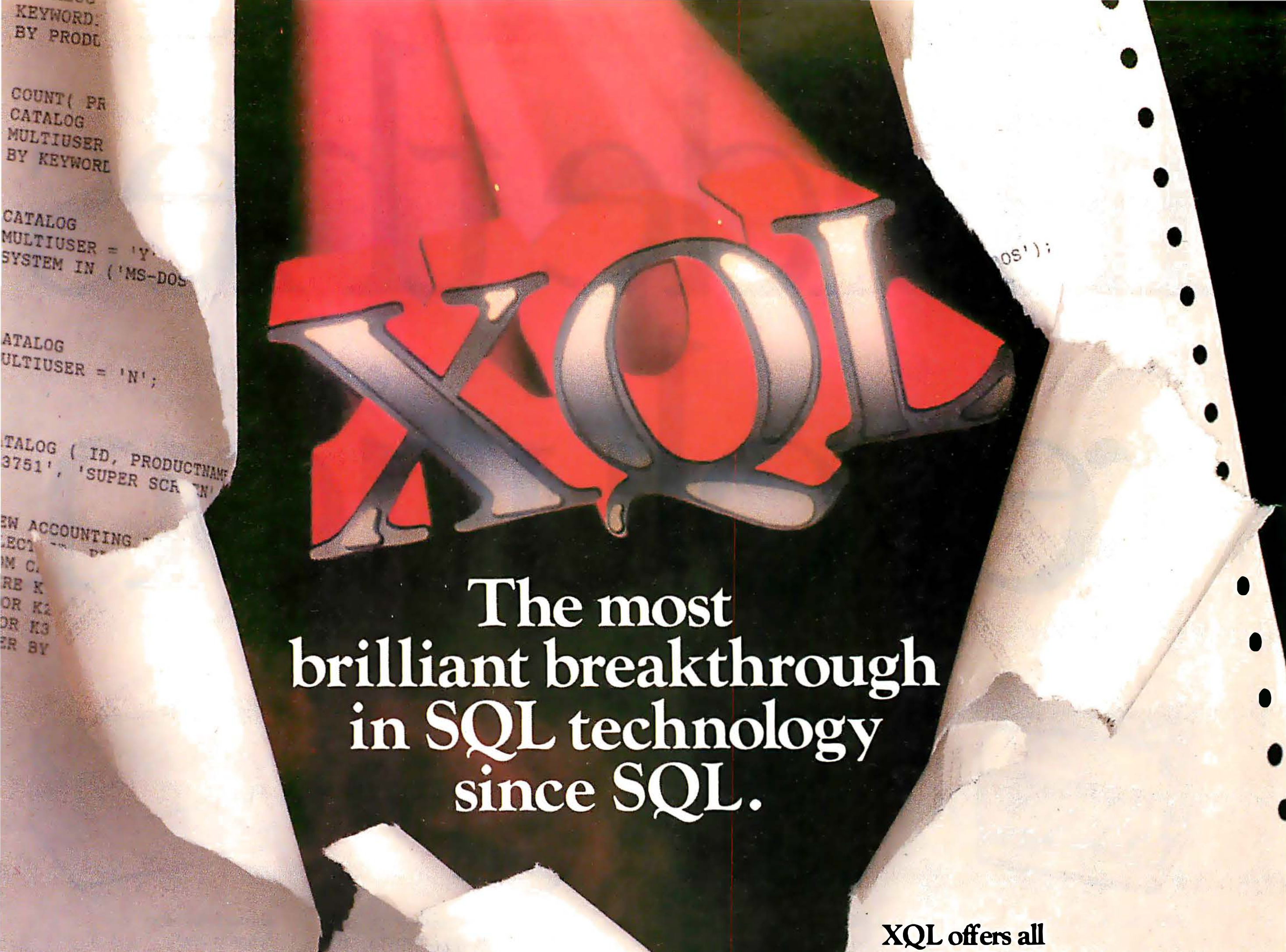
Actually, you might not have to pay $49 to get MultiFinder. Apple has stated that "MultiFinder is also available through other sources, including electronic distribution services and user's groups." This probably means that the files will be available on the major telecommunications utilities that are authorized to distribute Macintosh software. At the time this was written, Apple had not clarified its plans for distributing MultiFinder through these other channels. Since the $49 package, called the Macintosh System Software Update, includes documentation, three disks, and some new utilities, you might want to buy it instead of trying to download it all.

A potential Achilles' heel in MultiFinder is its dependence on the quality of third-party Macintosh software. Patrick Ross, one of the MultiFinder programmers, calls MultiFinder's new capability "cooperative multitasking," adding that MultiFinder depends on background applications being "well behaved"; that is, that they closely follow Apple's guidelines for Macintosh software.

Although handing such critical responsibility to third-party developers might be foolish in the IBM PC world, Apple developers have a record of very high compliance with Apple recommendations. Apple tells developers of the necessary guidelines long before they release the products that need them, thus ensuring that recently written applications will work correctly. In any case, Apple says MultiFinder will not crash, even when presented with ill-behaved software—it will simply close the offending application and issue an error message.

Overall, I'm personally impressed by what I've seen of MultiFinder so far and look forward to using it when the official version is released. ■

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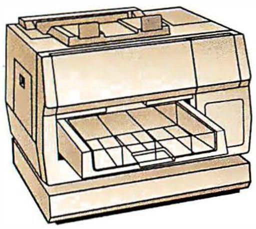
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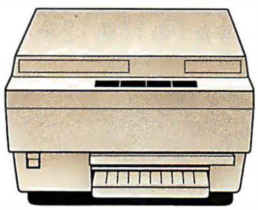
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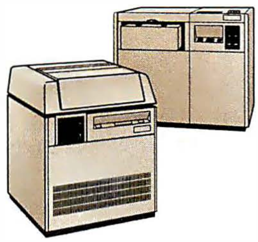
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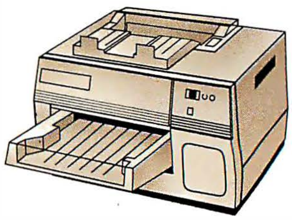
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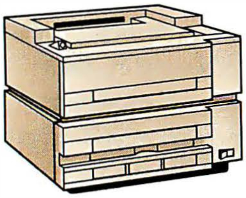
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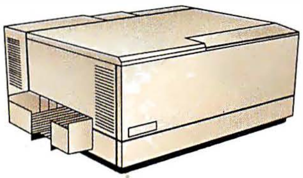
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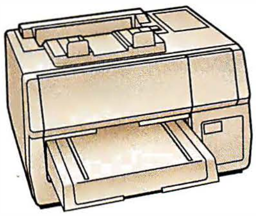
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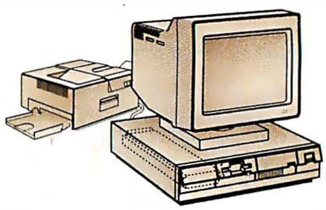
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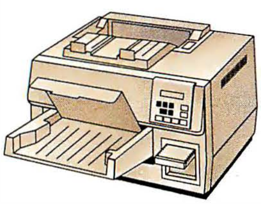
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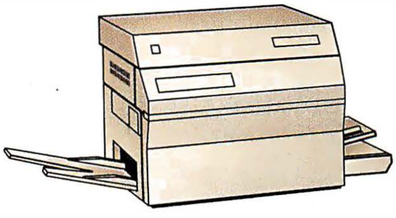
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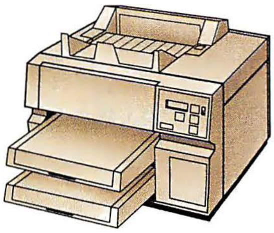
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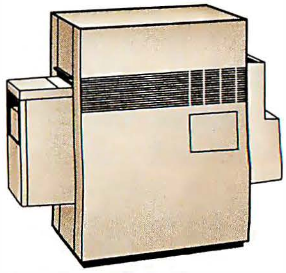
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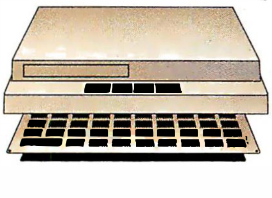
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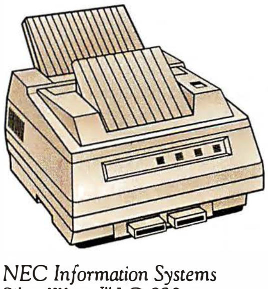
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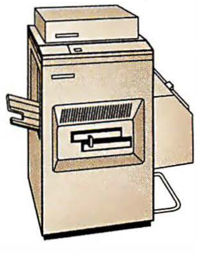
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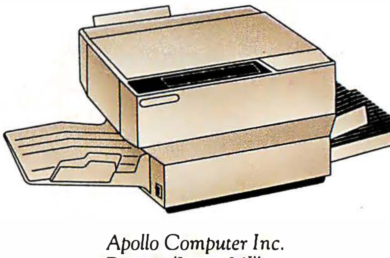
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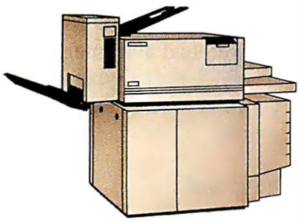


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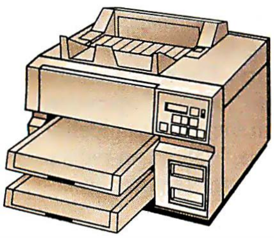


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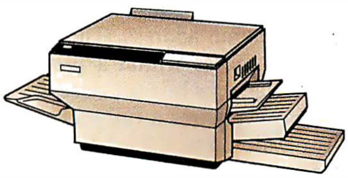
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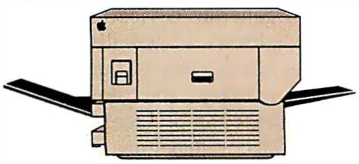
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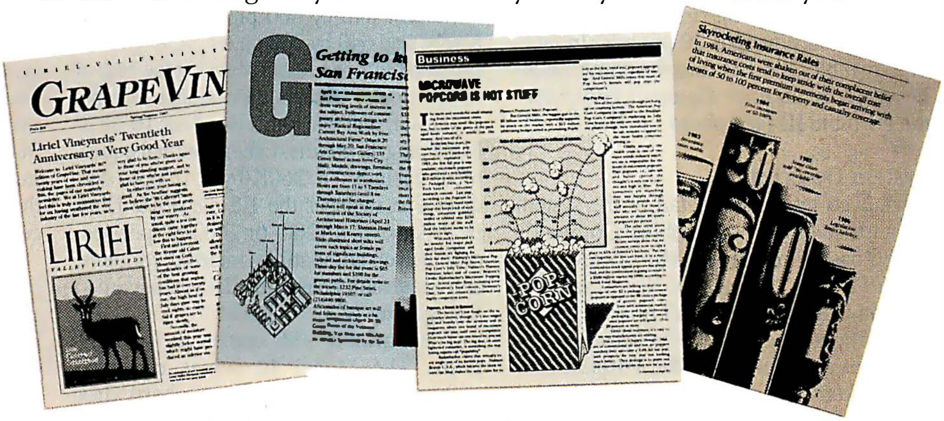


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The Compaq Portable 386

Tom Thompson

This 20-MHz 80386-based computer packs more power into a smaller housing

Just a year ago, Compaq introduced its first 80386-based computer, the Deskpro 386. Now Compaq has unveiled what it calls its "second-generation 80386 computer," the Compaq Portable 386.

Like its predecessor, the Portable 386 has an 32-bit 80386 CPU and a socket for an 80387 coprocessor and uses a paged-memory architecture to achieve high performance. However, the Portable 386 clocks these chips at 20 megahertz—25 percent faster than the Deskpro 386. Not only that, but while the Deskpro measures 20 by 16½ by 6½ inches and weighs 42 pounds, the Portable 386 measures 16 by 8 by 10 inches, reducing the machine's desk footprint by roughly 40 percent, and it weighs 20 pounds. In fact, the Portable 386 fits into the same housing used by another Compaq computer, the Portable III (see photo 1).

System Description

I won't go into much detail of the system because it closely resembles Compaq's 80286-based Portable III, already reviewed in BYTE (see "Compaq's New Carryon" by John Unger, May). I will provide a brief description, and, where necessary, I'll point out areas in which the Portable 386 differs from the Portable III in body and from the Deskpro 386 in soul.

The Portable 386 comes with an 80386 CPU that is user-switchable among speeds of 20 MHz, 8 MHz, and 6 MHz, to maintain compatibility with existing 80286 applications. It also has a socket for an optional 20-MHz 80387 math coprocessor. (Early versions of the Deskpro 386 could accept only an 80287 chip, since the 80387 was not yet shipping when the Deskpro 386 was first released.)

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The system has 1 megabyte of 32-bit RAM that has an 80-nanosecond access time. Like the Deskpro 386, the Portable 386's RAM can be expanded to 2 megabytes on the system board. The Portable comes with a 1.2-megabyte, 5¼-inch floppy disk drive that can read 360K-byte floppy disks. A built-in 10-inch-diagonal gas-plasma display has a 640- by 400-pixel resolution and can present 25 lines of 80 characters. It can display graphics in several modes: 640 by 400 pixels, 320 by 200 pixels, and 640 by 200 pixels. A 96-pin expansion bus connector located at the rear of the computer accepts an optional external expansion unit that holds two 8- or 16-bit 8-MHz plug-in boards. Other optional equipment includes a 360K-byte floppy disk drive that replaces the 1.2-megabyte floppy disk drive, a 1200- or 2400-bit-per-second Hayes-compatible internal modem, and expansion boards that let you add up to 8 megabytes of 32-bit RAM.

The Portable 386 comes in two versions. The Model 40 comes equipped with a 40-megabyte internal hard disk drive with an average access time of less than 30 milliseconds; it costs $7999. The Model 100 comes with a 100-megabyte internal hard disk drive with an average access time of less than 25 ms; this model is priced at $9999.

The Portable 386 can be expanded to 10 megabytes. You must first add RAM to the Portable 386's motherboard to its maximum of 2 megabytes, using a 1-megabyte memory upgrade kit. To add extra memory beyond this point, you need a 32-bit memory/modem interface board, which allows you to add a 4-megabyte memory-expansion board, followed by a 4-megabyte memory-extension board.

An optional tape/hard disk backup expansion unit attaches to the expansion bus connector and lets you save the contents of the hard disk to 40-megabyte cartridge tapes. The backup unit (see photo 2) uses DC-2000 tape cartridges, although it can read (but not write to) DC-1000 tape cartridges.

The system I reviewed had a 40-megabyte hard disk drive, 3 megabytes of RAM, an 80387 coprocessor, and an internal 2400-bps modem.

What's Under the Hood

The Portable 386 follows the Deskpro 386's design of carefully optimizing the throughput of the entire computer. This is evident in the use of high-speed hard disk drives, but the most performance is obtained by optimizing the computer's access to 32-bit memory. The memory subsystem uses a paged mode of operation that, combined with the address pipelining mechanism of the 80386, can reduce the number of wait states required to access RAM.

The Portable's 32-bit memory is composed of high-speed dynamic RAMs organized into physical pages of 2K bytes. During consecutive accesses within a page, a paged-memory cycle holds the row address of the DRAM constant while altering just the column address. Therefore, a sequential access within a page takes zero wait states, while an access outside of the page requires a full memory cycle of two wait states.

This arrangement fits in well with the address pipelining mode of the 80386, where it drives the address and definition of the next bus cycle onto the bus before the previous bus cycle has been acknowleged. This gives the memory-decoding circuitry time to generate device selects before the next address is actually accessed; thus, the bus activity of the next memory access overlaps the previous one. The new address can be accessed at once when a new bus cycle begins.

This paged-memory arrangement,

coupled with the 80386 pipelining mechanism, means that on the average, a 32-bit memory access will take less than one wait state, since programs often spend a lot of their time in small sections of code and, consequently, small portions of a memory-address range. Where the Portable 386 and the Deskpro 386 differ is that the Portable uses DRAMs, while the Deskpro uses static-column RAM.

The Portable 386 uses ST506-compatible disk controllers for the 40-megabyte or 100-megabyte hard disk drives. The bus transfer rates are 8 megabits per second and 10 megabits per second, respectively. While the Deskpro's 40-megabyte hard disk drive has the same access time as the Portable 386's, it has a transfer rate of only 5 megabits per second. However, the Deskpro 386 Model 130 has a 130-megabyte hard disk drive that uses an enhanced small device interface (ESDI) controller and has a transfer rate of 10 megabits per second.

Like Compaq's Portable III, the new computer uses application-specific integrated circuits (ASICs) to reduce the number of components in the computer. A paged-memory-controller ASIC processes CPU memory requests and determines if the address belongs on the internal 32-bit bus or the 16-bit expansion bus. For a 32-bit memory access, it also determines if the address is on the current page or a different one. If the address is on the current page, a paged memory cycle is used; otherwise, a full memory cycle is used to access the new page.

An expansion-bus-interface ASIC supplies the logic for the expansion-bus buffers and latches. The ASIC filters out 32-bit bus cycles so they don't appear on the expansion bus, and it translates CPU accesses to the bus into the appropriate expansion-bus signals. It performs data-size

continued



Note: Clear housing for photographic purposes only.

Photo 1: *Compaq's Portable 386 puts a high-speed hard disk, a 20-MHz 80386 CPU, and an 80387 math coprocessor in a Portable III housing.*

Compaq Portable 386

Company
Compaq Computer Corp.
20555 FM 149
Houston, TX 77070
(713) 370-0670

Size
16 by 8 by 10 inches; 20 pounds

Components
Processor: 20-MHz 32-bit Intel 80386; socket for optional 20-MHz Intel 80387 32-bit math coprocessor
Memory: 1 megabyte of 32-bit 80-ns memory on system memory board, expandable internally to 10 megabytes
Mass storage: 1.2-megabyte 5¼-inch floppy disk drive; 40-megabyte hard disk drive with less than 30-ms access time
Display: Red-orange 10-inch-diagonal flat gas-plasma with 80-column by 25-line text and three graphics resolutions: 640 by 400 pixels, 320 by 200 pixels, and 640 by 200 pixels; emulates IBM CGA and MDA
Keyboard: 91 keys; 12 function keys; indicator lights for Scroll Lock, Caps Lock, and Num Lock; separate numeric keypad
I/O interfaces: RS-232C port with DB-9 connector; DB-25 Centronics-compatible parallel printer port; RGBI monitor port with DB-9 connector

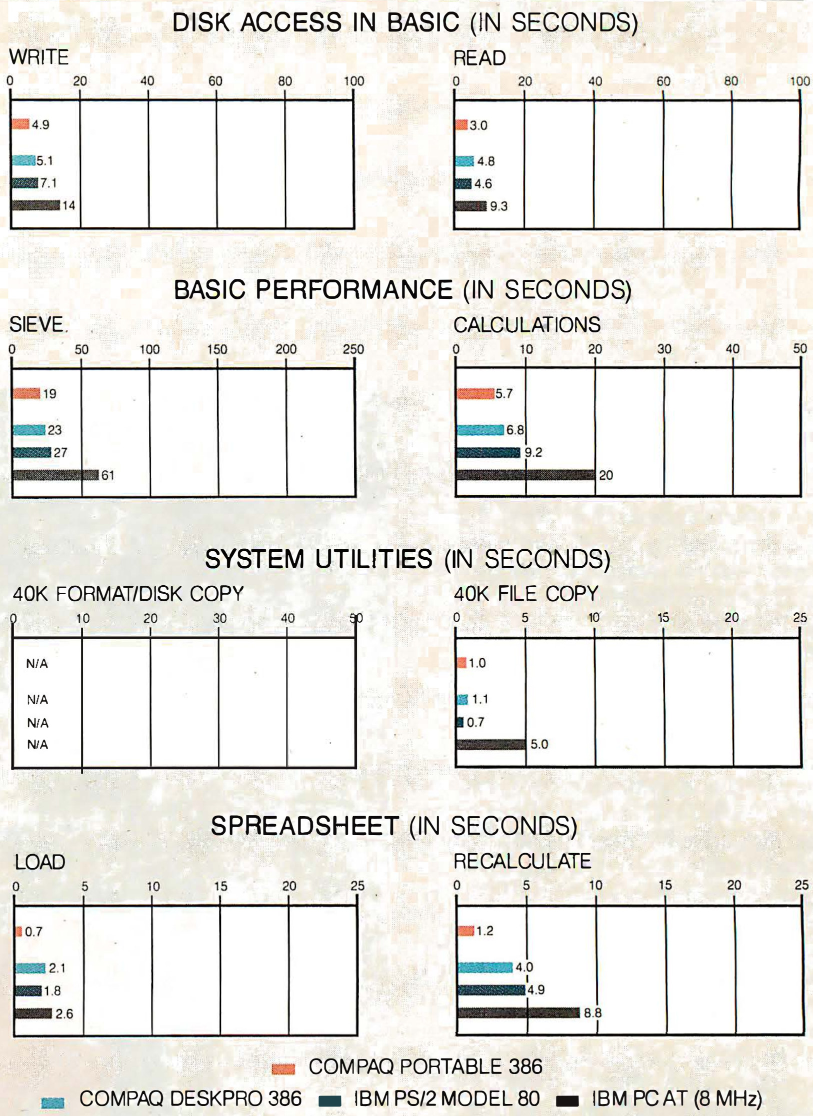
Software
Diagnostics test, system setup, and cache programs; expanded memory-management RAM disk

Options
20-MHz 80387 coprocessor: $1199
100-megabyte hard disk drive: $4299
40-megabyte tape/hard disk backup expansion unit: $999
Expansion unit: $199
1-megabyte memory upgrade kit for system board: $599
32-bit memory/modem interface board: $70
1- to 2-megabyte memory-expansion board (with 1 megabyte of RAM): $799
4-megabyte memory-expansion board: $2199
4-megabyte memory-extension board: $2199
1200-bps internal modem: $349
2400-bps internal modem: $699
MS-DOS BASIC and reference guide, version 3.3: $120
Compaq Portable 386 *Technical Reference Guide*: $149

Documentation
Compaq Portable 386 *Operations Guide*; Compaq Portable 386 *Supplemental Software Guide*

Price
Model 40: $7999
Model 100: $9999

Inquiry 886.



Test	Compaq Portable 386 20-MHz 80387	Model 80 16-MHz 80387	Compaq Deskpro 16-MHz 80387	Compaq Deskpro 8-MHz 80287	IBM PC AT 8-MHz 80287
Dhrystone*	4699	3626	3748	3748	1590
Fibonacci	42.29	57.26	53.11	53.12	126.22
Float	1.15	1.62	1.43	6.80	10.98
Savage	7.08	9.49	8.95	21.53	37.30
Sieve	4.76	6.45	5.98	5.99	24.60
Sort	6.15	7.74	5.58	5.58	43.17

(*Higher figures denote faster performance.)

The Disk Access benchmarks write and then read a 64K-byte sequential text file to a hard disk. Sieve runs one iteration of the Sieve of Eratosthenes. Calculations performs 10,000 multiplication and division operations. The 40K Format/Disk Copy benchmark is not performed on computers with only one floppy disk drive. The 40K File Copy benchmark copies a 40K-byte file on the hard disk. The Spreadsheet tests load and recalculate a 100-row by 25-column Multiplan (1.06) spreadsheet. Tests on the Portable 386 were performed using Compaq DOS version 3.2 and Compaq BASIC 3.2. Tests on the Deskpro 386 were performed using Compaq DOS version 3.1 and Compaq BASIC 3.11. The table contains the results of C language benchmarks (see "A Closer Look" by Richard Grehan in the September 1987 BYTE). All times are in seconds, except for the Dhrystone, which is in Dhrystones per second.

conversions as required. It can also generate bus cycles to allow devices on the expansion bus (typically direct memory access or I/O) to access the 32-bit memory.

The bulk of the system board support is handled by several ASICs. One ASIC contains the DMA page registers, the memory refresh counter, system ROM control, timer and keyboard processor clocking, and the real-time clock and keyboard logic. It also handles some addressing and restart control, nonmaskable interrupt logic, and the computer's speaker. Two other ASICs function as DMA and interrupt controllers and as interval timers. Finally, one ASIC manages the hard disk interface circuitry, the floppy disk controller and its interface, and the serial and parallel interfaces.

Software and Documentation

Interestingly, the Portable 386 comes with several useful utility programs, while the MS-DOS version 3.2 operating system, which includes Compaq's version of BASIC, is optional. The utility programs, provided on self-booting 5¼-inch floppy disks, let you configure your system, test it, and format the hard disk.

There's also a memory-management program, a disk-caching program, and a RAM disk program. The Compaq Expanded Memory Manager (CEMM) program allows applications following the Lotus/Intel/Microsoft (LIM) standard to use more than 640K bytes of memory. The disk-cache program lets you set up a cache memory for the computer's hard disk to improve performance. You can select the amount of memory to use for the cache and whether to allocate it from extended memory. The cache program cannot be used with floppy disk drives.

The documentation supplied with the Portable 386 that I reviewed included preliminary versions of the computer's *Operations Guide* and *Supplemental Software Guide*. The *Operations Guide* explains how to set up the computer and get it running. The *Supplemental Software Guide* covers how to use the CEMM, the disk-cache program, and the RAM disk. It also has information on several utilities that configure and allow applications to use the plasma screen display.

Also in preliminary form was the Portable 386's two-volume *Technical Reference Guide*. This well-organized manual presents a wealth of information for the serious programmer. It provides timing diagrams and detailed descriptions of the system, and it thoroughly documents the BIOS calls.

Performance and Compatibility

The Portable 386 ran all typical applications quickly and with no problems. XyWrite 3.06B ran normally on the plasma display and responded properly to all the function keys. The Portable 386's speed is impressive. I was able to use the XyWrite word processor as an editor for modifying the C timing routines, rather than using a programming editor. The plasma display was readable under the fluorescent lights in my office, although I had to crank up the display intensity to its maximum setting to read it.

The internal modem worked with Pibterm 3.2.5 and responded properly to typed Hayes modem commands. Pibterm initially refused to dial a number because it thought there was a "session in progress." A glance in a Hayes modem manual led me to issue an `AT&C1` command, which told the modem not to generate a carrier detect on condition, but to look for it externally from a remote station. From this point, Pibterm worked without a hitch and thus verified the modem's Hayes-command compatibility. I communicated with several bulletin board systems at 2400 bps without problems.

I ran the now-traditional C language BYTE benchmarks compiled with MetaWare's High C compiler and using Phar Lap's RUN386 version 1.3 protected-mode environment. Unfortunately, the Portable 386's CEMM won't run with an application operating in the protected mode. However, rather than hang the system, CEMM politely steps out of the way by prompting: `CEMM Privileged operation error # 05 - Deactivate CEMM and Continue (C) or reBoot (B) (B or C)?` Typing a `C` at this point allowed the benchmarks to continue. Once the CEMM is deactivated, it stays that way until you reactivate it using the CEMM command.

To properly evaluate the Portable 386's performance with its CEMM, I also compiled the benchmarks using Microsoft C version 4.0. To make the Microsoft compiler's output resemble the High C code as much as possible, I had the compiler optimize the object code, use the large memory model, and generate 80286 instructions (it does not produce native 80386 code). The compiler optimized the application for speed rather than for size, and stack-checking code was eliminated. The results of the Microsoft C compiler tests, with and without CEMM, are shown in table 1.

As far as measured performance goes, the Portable 386 has the field to itself. Up to now, the Deskpro 386 has led the pack in the C language benchmarks with the machines tested here. The Portable 386 has

continued

The Compaq Deskpro 386/20

Compaq plans to introduce a second-generation version of its Deskpro 386 computer: the Deskpro 386/20. As the name suggests, the 80386 CPU will be clocked at 20 MHz. The computer can use either a 20-MHz 80387 math coprocessor or the 80386-compatible WTL1167 math unit from Weitek Corp.; the CEMM software has been modified to allow MS-DOS to access the Weitek unit.



The computer will also use Intel's new 32-bit 82385 cache-controller chip. The 82385 can address the 80386's entire 4-gigabyte address space and implements the cache directory, or tag RAM, on-chip. The 82385 and a high-speed cache, composed of 32K bytes of static RAM with a 35-ns access time, are used to improve system performance.

The Deskpro 386/20 comes with 1 megabyte of 100-ns RAM, upgradable to 16 megabytes. Due to the cache, faster memory is not required. The Deskpro 386/20 offers several choices in mass storage: a 60-megabyte hard disk with less than 30-ms access time, a 130-megabyte hard disk with less than 25-ms access time, or a 300-megabyte hard disk with less than 20-ms access time. The system comes with a 1.2-megabyte 5¼-inch floppy disk drive, and a 1.4-megabyte 3½-inch floppy disk drive is available as an option. Also available is a 135-megabyte internal tape drive that uses DC-600 tape cartridges.

What of the Deskpro 386? The Model 40 will continue to be sold as an entry-level computer. However, the Models 130 and 170 will be eliminated, to be replaced by the higher-storage-capacity versions of the Deskpro 386/20.

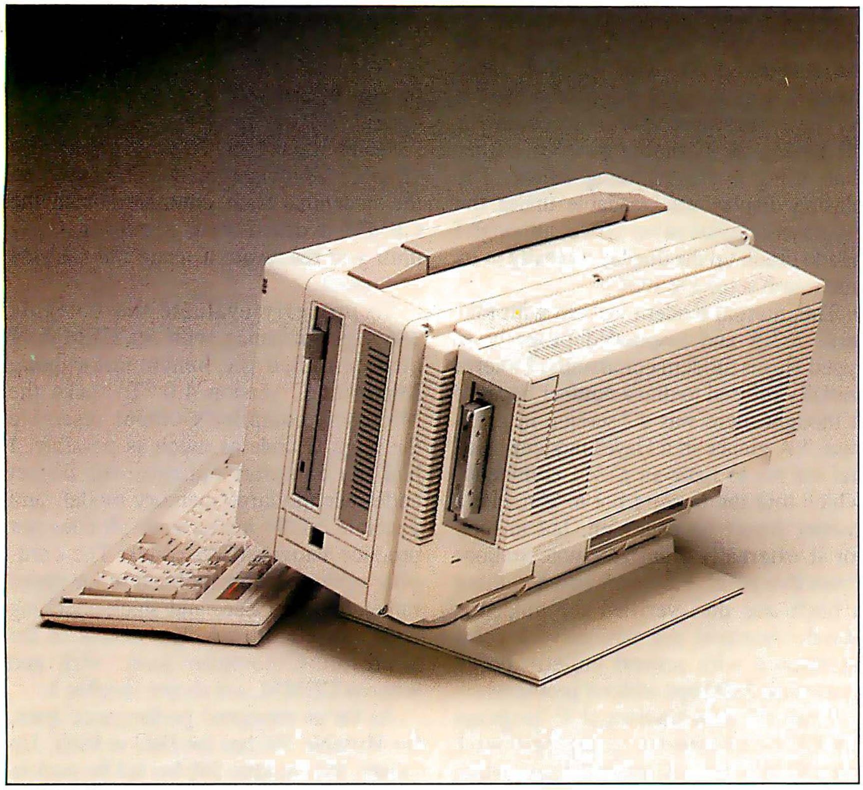


Photo 2: *The Portable 386 with a standard housing and an optional tape/hard disk backup unit attached to the back of the computer.*

Table 1: *A comparison of the C language benchmarks running with or without the Compaq Expanded Memory Manager (CEMM). Since the CEMM can't run protected-mode programs, only the Microsoft C-compiled versions of the benchmarks were run. The Microsoft C compiler used was version 4.0, and it generated optimized 80286 code using the large memory model. All times are in seconds, with the exception of the Dhrystone results, which are in Dhrystones per second. Dhrystone parameters are the same as in the table on page 136.* "CEMM on" *means the memory manager was in use;* "CEMM off" *means the memory manager was disabled. These results are not directly comparable to the results in the table on page 136.*

Benchmark	Dhrystone	Fibonacci	Float	Savage	Sieve	Sort
Operating mode						
CEMM on	4166	53.73	1.24	9.67	9.87	16.20
CEMM off	4166	53.66	1.21	9.67	9.87	16.17

Table 2: *Results of the floating-point benchmarks using Microsoft C, with and without use of a math coprocessor. Note the additional time it took the benchmarks to run with the CEMM enabled. All times are in seconds.*

Benchmark	Float	Float (80387)	Savage	Savage (80387)
Operating mode				
CEMM on	43.19	1.24	324.94	9.67
CEMM off	26.58	1.21	210.36	9.67

pushed the stakes higher with its faster clock rate. The Portable 386 measures in at 4699 Dhrystones per second, and it comes as no surprise that it's 20 percent faster than its nearest competitor: the Deskpro 386, running at 3748 Dhrystones per second. In fact, the Portable 386 places 20 percent faster than the Deskpro in every benchmark except the Sort.

Incidentally, Compaq has announced a successor to the Deskpro 386 that should return that machine to its lead position in the benchmarks. See the text box "The Compaq Deskpro 386/20" on page 137 for details.

For the most part, the effect of the CEMM on benchmark performance is minimal until you look at the floating-point math benchmarks using the software-emulation libraries, as shown in table 2. Using the CEMM adds about 16 seconds to the Float benchmark and 114 seconds to the Savage benchmark. This is the penalty you pay in performance to be able to access additional RAM. Compaq warns you of this side effect in the *Supplemental Software Guide*, and the company recommends that you disable the CEMM if performance is a problem.

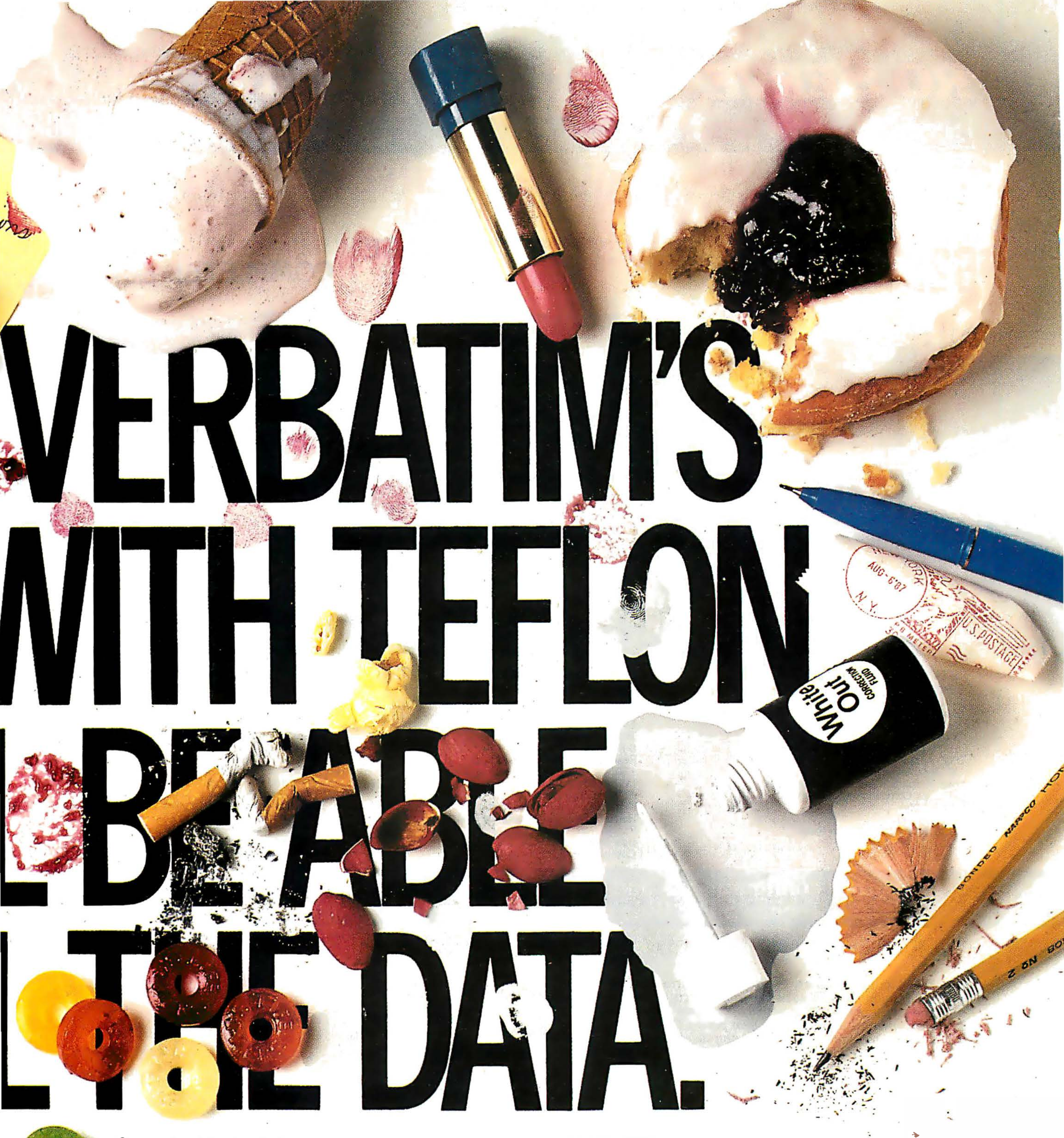
If you are content to operate within 640K bytes of memory, then you can live without CEMM. But if your work requires that you process megabytes of data or run large programs, then you'll have to accept the overhead of CEMM. Note that you must expect this type of overhead in any program that uses more than 640K bytes of memory, not just with programs running floating-point math.

A Good Thing in a Small Package

I have only a few complaints with this machine, most of them minor. The keyboard cable on the unit is far too short: The keyboard kept sliding toward the machine and to the right as I tried to work. I would like to have a 3½-inch floppy disk drive as an option, although I can understand Compaq's desire to support customers who own drawers full of 5¼-inch floppies. Finally, for the price, the machine is possibly too portable: Somebody could easily walk out of an office with this $7999 computer. A provision for a security cable should be provided.

On the positive side, the Portable 386 currently has no rival in the areas of processing power, as well as a housing that won't rob you of precious desktop space. Many Portable 386s will be purchased to bring the power of the 80386 to bear on large computing problems, and then, if necessary, carried home to finish the job. Those who travel a lot and keep in touch with work via their portable computers will welcome the addition of the 2400-bps speed. ■


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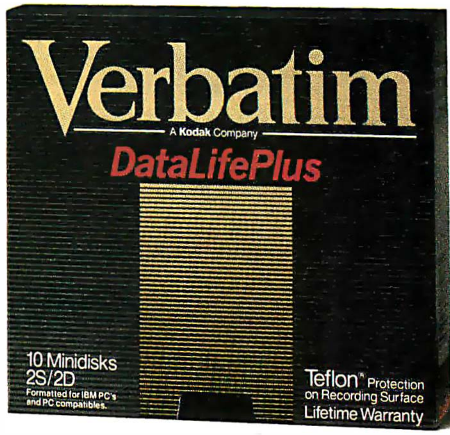
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Seagate 20Mb for AT ST225	289
Seagate 30Mb for AT ST4038	529
Seagate 40Mb for AT ST251	499
Seagate 80Mb for AT ST4096	929

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EGA Monitor w/Card	569

ADD-ON BOARDS

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The IBM PS/2 Model 80

Curtis Franklin Jr. and Richard Grehan

How does IBM's new 80386-based tower of power measure up?



Anticipation of the IBM PS/2 line of computers centered around one machine: the Model 80. The top of the PS/2 line, this 80386-based computer is the new standard-bearer for users of MS-DOS systems. The Model 80 makes use of all the new features of the PS/2 family, including the Micro Channel, VGA graphics, and, in some configurations, an ESDI (enhanced small device interface) hard disk. OS/2 is intended to be the operating system of choice on the Model 80; for now, however, the Model 80 is going head-to-head with the Compaq Deskpro 386 and other 80386-based microcomputers as a fast MS-DOS system.

The Model 80 is available in a number of different configurations. As the cost of the system goes up, so does the capacity of the hard disks and, at the top price levels, the clock speed of the system. Features of the various Model 80s range from a low-end configuration with a 16-megahertz 80386 and a 44-megabyte hard disk drive to a high-end configuration with a 20-MHz 80386 and a 314-megabyte ESDI hard disk drive.

The computer we reviewed was the PS/2 Model 80-041, the lowest-level Model 80, which comes with 1 megabyte of RAM; a 44-megabyte hard disk; serial, parallel, keyboard, and pointer-device (mouse) ports; a 1.44-megabyte floppy disk drive, and VGA graphics. The 80386 CPU in the Model 80-041 runs at 16 MHz. For benchmarking, we installed an 80387 math coprocessor in the review unit. As reviewed, the Model 80 has a suggested retail price of $6995.

[Editor's note: *For further information on the PS/2 series of computers, see the following articles in previous issues of BYTE: "First Impressions: The IBM PS/2 Computers," June; "The IBM PS/2 Model 30," July; "The IBM PS/2 Model 50," July; "The New Generation: High-Tech Horsepower," July; "The New Generation: Head to Head," August; "The New Generation: Under the Covers," August; "The Technical Implications of the PS/2," 1987 IBM Special Issue; "The 32-bit Micro Channel," 1987 IBM Special Issue; "PS/2 Video Programming," 1987 IBM Special Issue; "Comparing IBM's Micro Channel and Apple's NuBus," 1987 IBM Issue.*]

The New Look

The Model 80 shares the new look of IBM personal computing with the other members of the PS/2 line. In fact, it is difficult to look at a Model 60 and a Model 80 from a distance and tell the difference. The tower configuration of the Model 80 is well suited for placing the rather large and heavy system box on the floor next to a desk, and beside a desk is the proper location for this box. There is a handle on the Model 80, and it works well, but this does not imply that the 45-pound unit is portable. In the BYTE computer lab, where computers are rearranged on an almost daily basis, the Model 80 has remained firmly rooted in the spot it first touched down.

Like all the other PS/2 computers, the Model 80 uses the 101-key IBM enhanced keyboard design. This keyboard keeps most of the good design features worked out through the evolution of the PC AT and loses only a few nice touches from earlier keyboards, most noticeably the extra-large Return key from the original PC AT. Separate numeric keypad and cursor keys, indicator lights for Caps, Num, and Scroll Lock, and 12 function keys stretched across the top of the keyboard complete the tour. The feel of the keys is stiff and positive.

We used the Model 80 with an 8513 color monitor, which is slightly smaller (1 inch diagonally) than the 8512 but has a 28-millimeter dot pitch versus the 32-mm dot pitch of the 8512. The combination of fine dot pitch and etched nonglare screen make the 8513 monitor a good choice for most applications.

On the Inside

Externally, the Model 80 looks just like a Model 60, but once you crack the case

continued

Curtis Franklin Jr. is a BYTE associate technical editor, and Richard Grehan is a technical editor. They can be reached at One Phoenix Mill Lane, Peterborough, NH 03458, or on BIX as "curtf" and "rick_g."

IBM PS/2 Model 80

Company
IBM Corp.
113 Westchester Ave.
White Plains, NY 10604
(800) 447-4700

Size
19 by 23½ by 6½ inches; 45 pounds

Components
Processor: 80386 running at 16 MHz with one wait state; socket for optional 80387 math coprocessor running at 16 MHz
Memory: 1 megabyte of 80-ns RAM, expandable to 4 megabytes with 2-megabyte daughterboards; 128K bytes of ROM
Mass storage: 1.44-megabyte 3½-inch floppy disk drive; 44-megabyte hard disk
Keyboard: 101-key enhanced PC AT keyboard
I/O interfaces: Serial port with DB-25 male connector; parallel port with 25-pin female connector; 6-pin pointing-device (mouse) connector; 6-pin keyboard connector; 15-pin VGA graphics connector
Graphics: VGA standard graphics—720 by 400 text; 640 by 480 graphics (16 of 256,000 colors); 320 by 200 graphics (256 of 256,000 colors); 256K bytes of video RAM

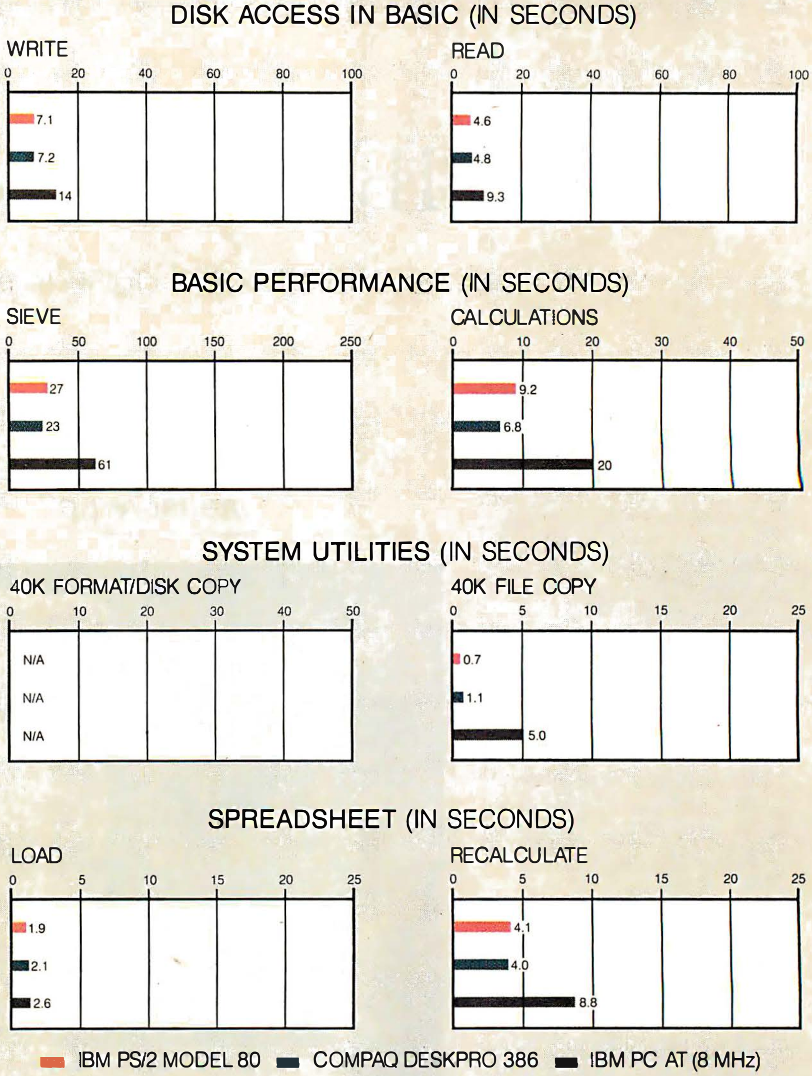
Documentation
IBM PS/2 Model 80 User's Guide

Software
Disk cache software, setup programs

Options
8503 monochrome monitor: $259
8512 color monitor: $595
8513 color monitor: $685
8514 color monitor: $1550
8514 display adapter: $1290
1-megabyte memory expansion: $695
2-megabyte memory expansion: $1295
Personal System/2 mouse: $95
Data migration facility: $33
IBM DOS 3.3: $120

Price
Model 8580-041 with 1 megabyte of RAM, a 16-MHz 80386, and a 44-megabyte hard disk: $6995
Model 8580-071 with 2 megabytes of RAM, a 16-MHz 80386, and a 70-megabyte hard disk: $8495
Model 8580-111 with 2 megabytes of RAM, a 20-MHz 80386, and a 115-megabyte hard disk: $10,995
Model 8580-311 with 2 megabytes of RAM, a 20-MHz 80386, and a 314-megabyte hard disk: $13,995

Inquiry 883.



Test	Model 80 16-MHz 80387	Compaq 386 16-MHz 80387	IBM PC AT 8-MHz 80287
Dhrystone*	3626	3748	1590
Fibonacci	57.26	53.11	126.22
Float	1.62	1.43	10.98
Savage	9.49	8.95	37.30
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(*Higher figures denote faster performance.)

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and go inside, things change. You find an 80386 running at 16 MHz, 128K bytes of ROM, 1 megabyte of 80-nanosecond dynamic RAM (expandable to 4 megabytes using IBM daughterboards), a socket for an 80387 floating-point coprocessor, and lots of on-board I/O hardware. Additionally, the system contains battery-backed CMOS RAM that consists of 64 bytes associated with the clock/calendar, and a 2K-byte CMOS RAM extension, used by the system to store configuration and diagnostic information. (IBM documentation isn't clear about what the system actually stores in this extension RAM, simply stating that it is reserved).

The motherboard bears 10 slots of various configurations. Two, toward the top of the board and just beneath the power supply, accept memory modules of 1 megabyte each. The remaining slots are Micro Channel connectors: four 16-bit and three 32-bit channel connectors and a 16-bit connector with the video extension. The topmost 16-bit channel connector holds the hard disk controller card.

As with other members of the PS/2 line, most of the common I/O hardware is provided on the Model 80's motherboard. Looking at the back of the machine and proceeding from top to bottom, you'll see the keyboard connector, an auxiliary device (i.e., mouse) connector, a connector for a parallel printer, a DB-25 RS-232C serial connector, and the video connector (a 15-pin D-shell driven by the Model 80's VGA system.) This is the same video system as on the Models 50 and 60.

The Model 80's 3½-inch disk drive controller circuitry is also provided on the motherboard. Up to two drives attach in daisy-chain fashion via a 40-pin connector mounted in the upper-right side of the machine (as viewed from the side that opens). You can format floppy disks to either 720K bytes or 1.44 megabytes. A snap-out panel on the front of the Model 80 opens to a mounting framework capable of holding two half-height or one full-height 5¼-inch floppy or hard disk drives. (Adding a second hard disk drive would be a simple matter of putting together the proper cables: The controller board has the extra connector, and there's an additional plug on the power supply that's obviously meant for a drive. Adding a 5¼-inch floppy disk drive would be a little more difficult—you would need a controller board as well as the drive itself.)

Memory-access time on the Model 80 depends on which device is performing memory operations. The 80386 CPU accesses memory—ROM as well as RAM—with a cycle time of 187.5 ns (including 1 wait state of 62.5 ns); the direct memory access system runs at 8 MHz and drives memory at a 375-ns cycle time, including one wait state of 125 ns. IBM's documentation indicates that the DMA controller must perform a minimum of two cycles per read or write operation, and a minimum of three cycles whenever it accesses the system board memory.

You can expand memory on the Model 80 via expansion cards on the Micro Channel (when such cards become available), up to a total system memory capacity of 20 megabytes. However, the addressing range of the DMA system is limited to 16 megabytes, and IBM's documentation recommends limiting memory to this 16-megabyte ceiling.

Software

The only software that comes with the Model 80 is a setup disk that installs the disk cache, sets the clock/calendar, and performs other initializing functions. We used PC DOS 3.30 as the operating system; we installed it easily, since it comes on both 5¼- and 3½-inch disks. Most software vendors have announced that they will begin selling software in the dual-disk formats, but few packages were available on 3½-inch disks in time for this review, so we also got to exercise data-transfer software.

In the past, we've used Traveling Software's LapLink to move software between machines. It worked quickly and well on a number of laptop computers and on the PS/2 Model 30. On the Model 80, it locked the machine. According to the information screens, the first file went to the Model 80 from the PC AT, but no acknowledgment was sent. The only recourse was to reboot the Model 80, but even then there was a startup error (error number 1101) as long as the LapLink cable was attached to the serial port. We finally picked up the IBM Data Migration Facility (DMF) and used it to transfer files from the AT to the Model 80. It doesn't have nifty menus, and it will not transfer files from the Model 80 back to the AT, but it is simple enough to use and goes about its business quickly.

We ran a number of applications packages on the Model 80; all of them ran with no obvious problems. Lotus 1-2-3 (version 1A) flies on the Model 80. XyWrite III, Norton Commander, and Publisher's Paintbrush 1.0 all work very well. AutoCAD version 2.17 (with ADE-3 extension) loads and redraws quickly, and while no one will mistake a Model 80 with AutoCAD for a high-end workstation, it is fast enough to make detailed drawings possible in a reasonable period of time. The only problem with AutoCAD came about with CADLisp, the programming language provided with the package. On three different occasions, we got a message that there was insufficient memory, and CADLisp was disabled. This didn't affect the rest of the program, and we could find no pattern to the problem's occurrence.

The Model 80 offers conservative performance at a relatively high price.

To test a database package, we tried Reflex and found that the program ran quite well, with the same boost in performance found with other software.

Point and Shoot

The Model 80 that we reviewed did not come with an IBM mouse, but we attached a new Microsoft PS/2 InPort Mouse to it. This mouse functioned well with all but one software package; even Norton Commander, which had problems with the IBM mouse on Model 30s and Model 50s, made good use of the mouse on the Model 80.

Unfortunately, the program that didn't "see" the mouse is a program that most people agree desperately needs one: Microsoft Windows. Using Windows version 1.03, we tried listing every point-

continued

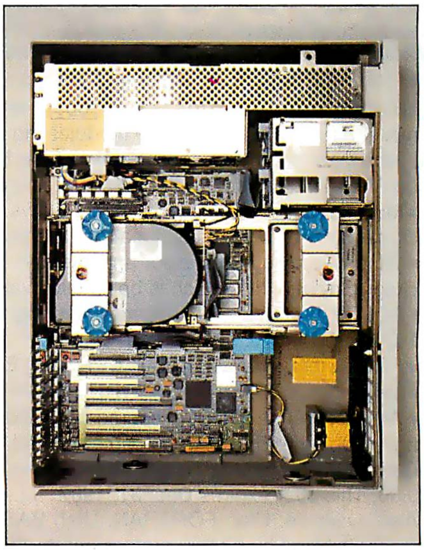


Photo 1: *The interior of the computer, with panel removed. The power supply is at top. Memory mounts between power supply and hard disk. Micro Channel expansion slots (16- and 32-bit) are at bottom left. A second hard disk drive would mount in the rails at right center of the photo.*

ing device on the setup menu, to no avail. Windows ran, but it could take commands only from the keyboard. It was not until we tried an alpha-release (very early testing) version of Windows 2.0 that the Microsoft Mouse was recognized. This version ran with no discernible problems, although we did not try to run any of the third-party software designed to run with Windows.

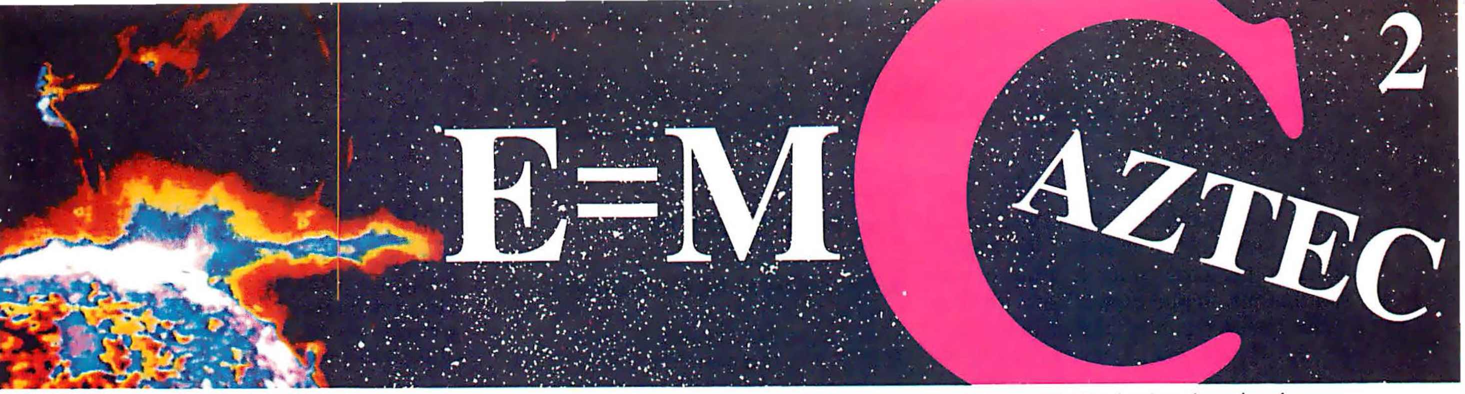
The Verdict (For Now)
Much has been made of the performance competition between the PS/2 Model 80 and Compaq Deskpro 386. The benchmarks were run with numeric coprocessors installed on all machines. We found that the benchmarks indicate a decided advantage for the Compaq. There was not a single C language benchmark for which the Model 80 posted a faster time than the Compaq.

IBM has created a huge problem for anyone trying to analyze the Model 80, or any of the PS/2 line. In announcing the PS/2 family of computers, IBM stressed that the Model 80 is designed to support multitasking, high-performance single-user applications, and multiuser installations. These roles depend on systems software, applications software, and connectivity hardware and software, none of which is currently available. So, for now, the Model 80 must be judged against a host of 80386-based computers, led by the Compaq Deskpro 386, as a very fast MS-DOS machine. How does it compare with these?

Users have come to expect IBM microcomputers to be conservative in performance and relatively high in price. The Model 80 does not disappoint in either of these respects. For most operations, the Deskpro is a faster computer. In disk operations, the ALR 386/2 matches the speed of the Model 80. Each of these competitors can be purchased at a lower price than the Model 80. In addition (and a point that we have not dwelled on in this review), almost all the other 80386 computers can make use of expansion boards currently on the market.

Although the Micro Channel has much to recommend it from a technical perspective, the fact remains that there are precious few boards currently available for the bus. Admittedly, this is less of a problem for the PS/2 family than for previous IBM computers, since more basic functionality is built into the computers as they come from the factory. However, if you are used to modifying your machine to fit your needs, and especially if those needs are somewhat specialized, the dearth of add-ins can be a severe constraint.

continued



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The Model 80, like most IBM products, is solidly engineered and well built. The modular construction of the Model 80 takes personal computers out of the world of the "home-brewer" and into the white-coated realm of professional computing. The PS/2 family marks an important turning point in the relationship of microcomputer users to their machines. In the new IBM world, the days of jumper wires and "hardware hacks" seem destined to become a fading memory.

The most important question for the buyer of an 80386 computer is whether to wait for the promises of IBM to materialize or make use of what is here now. If you need a fast, powerful computer to run MS-DOS programs, there are 80386-based ways to do it that cost less and show performance equal to or better than the Model 80. The competitors also have the crucial ability to make use of existing hardware for expansion.

If, on the other hand, you need the capabilities that IBM has talked about, and if networking, talking to IBM mainframes, and using (still-under-development) Micro Channel add-ins are important to you, then the PS/2 Model 80 is, quite frankly, the only game in town. We hope the prize will be worth the wait. ■

VIEWS FROM BIX: THE PS/2 MODEL 80

ibm.ps/reviews #2, from John Gotwals.

1. How do you justify your statement that OS/2 is "the operating system of choice on the Model 80?" First of all, OS/2 will not (at least at first) use any 386-specific features. In fact, we have to wait for either Windows 386 or OS/3. Second, IBM will "soon" announce AIX for the Model 80. Maybe AIX will allow DOS programs to run as a task under AIX?

2. If you purchase the 80386 memory-expansion option, you will get 2 megabytes for $1595. Your article does not mention that you can add memory to this board by purchasing 2-megabyte expansion kits for $1295 each. You can add up to two kits, for a total of 6 megabytes of memory per 32-bit slot.

3. Your review should mention that the Setup disk (reference disk) includes advanced diagnostics. Pressing Control-A at the main menu will bring up the advanced diagnostics. For some reason, this feature is not mentioned in the Quick Reference document that comes with the computer, but the Service Manual, part number 68X2255, contains this information.

ibm.ps/reviews #3, from Glen Sunada.

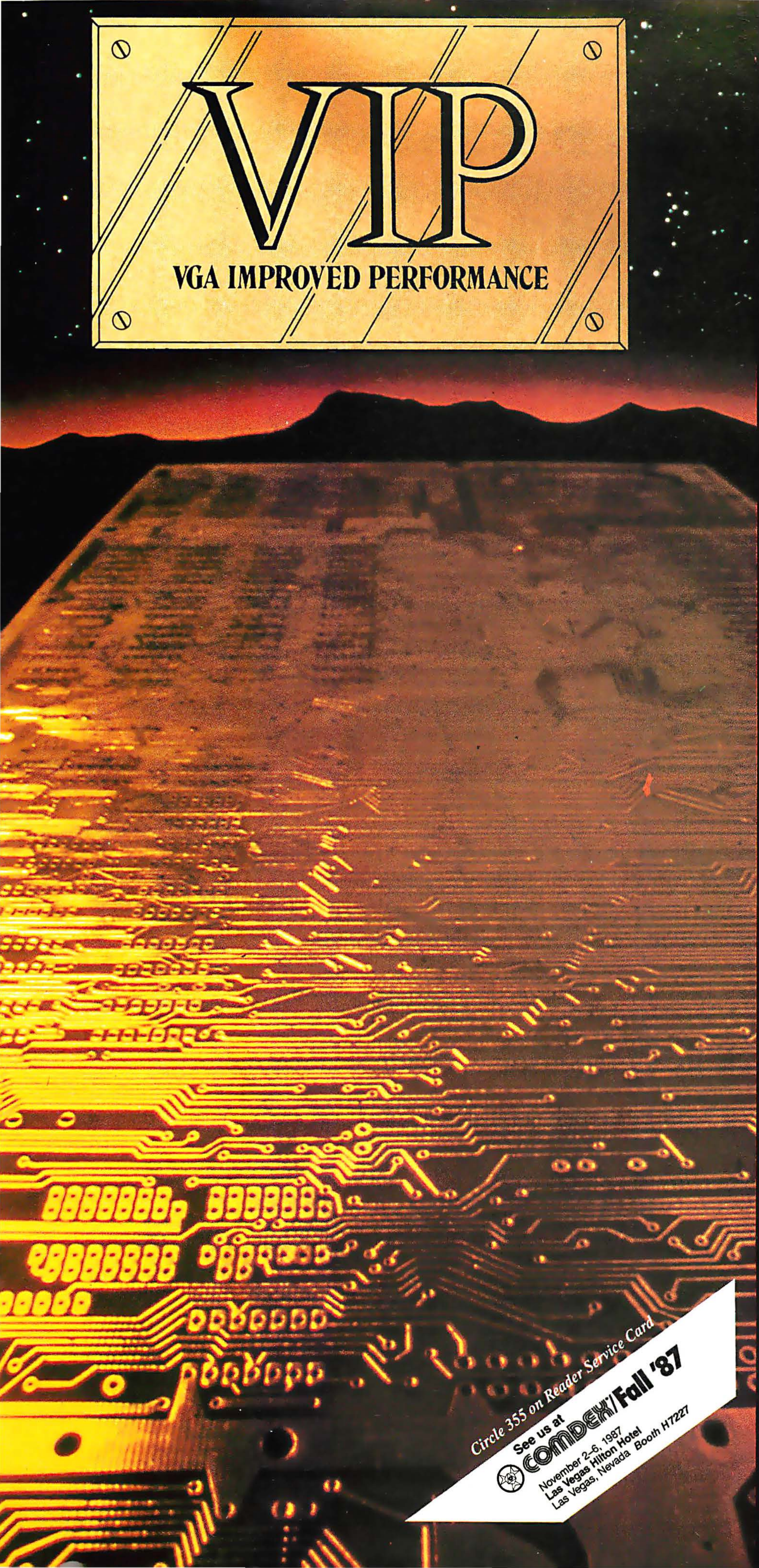
OS/2 trashes the 32-bit registers of the 80386 and therefore does not look like the operating system of choice. I would prefer to use the Xenix operating system on the Model 80.

ibm.ps/reviews #9, from Barry Nance.

Anyone planning on using power connectors from the power supply (for any reason whatsoever) should realize that (a) the cable connectors are slightly different from those used in previous machines (e.g., XTs and ATs), and (b) there are only three outlets: one special harness that goes to the motherboard, one cable that goes to the hard disk drive, and a third empty outlet. That's all there is from the power supply.

ibm.ps/reviews #10, from Eric S. Klein.

You neglected to mention the biggest software incompatibility of the Model 80: The OS/2 developer kit will not run on it! So if you wish to develop projects for OS/2, you'd better buy a Compaq. If you don't care about OS/2, then the Model 80 is a fine machine to buy.



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[2] Compaq via optional Compaq Expansion Module

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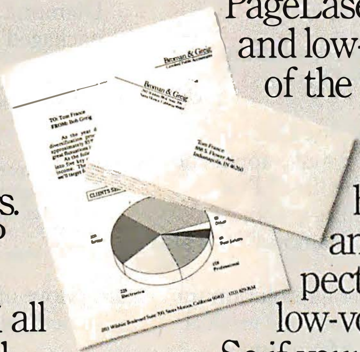


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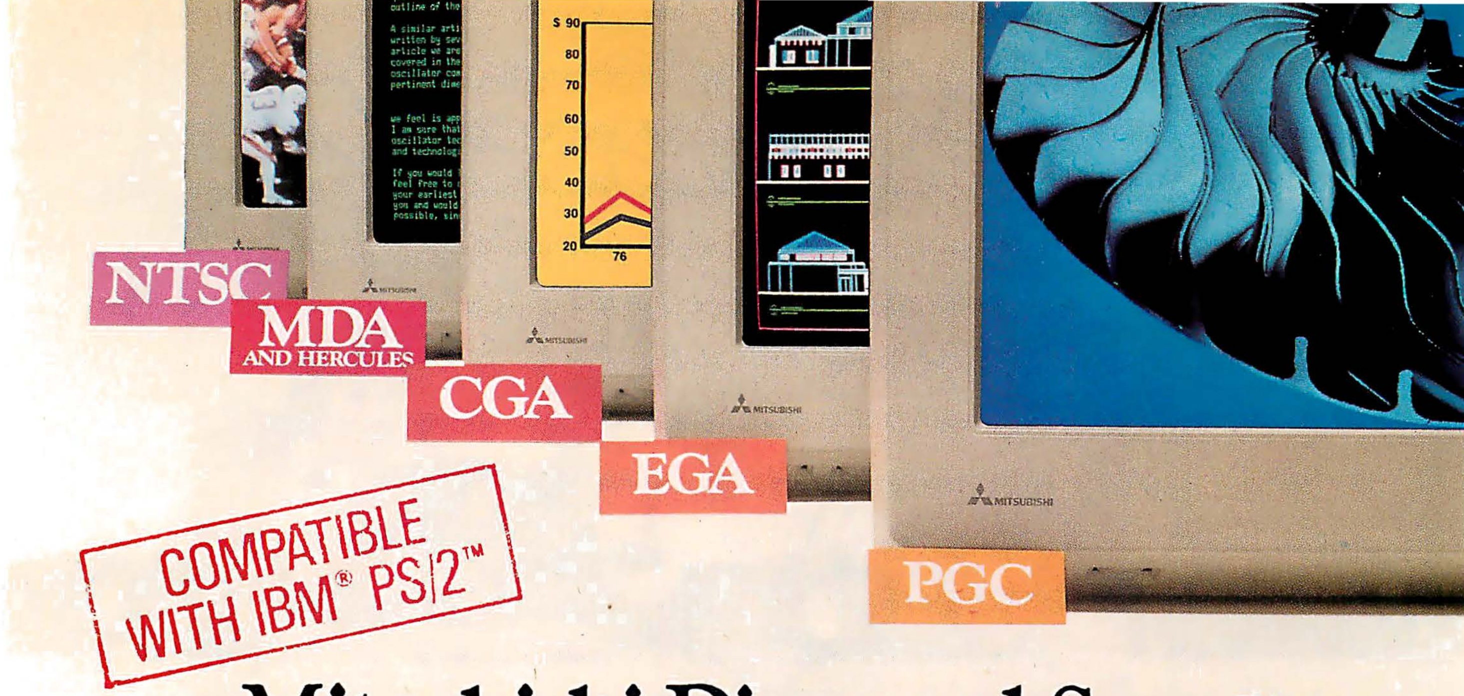
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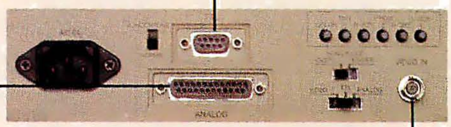


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Acer 1100 and Micro 1 386+

by Ed McNierney

Two powerful 80386 computers with high-speed hard disk systems

As systems based on the 80386 processor proliferate, they are changing from high-priced, premium machines to machines nearer the price range of AT-class computers. This affordability does not necessarily compromise performance, however, since many of the newer systems provide distinct improvements over earlier 80386 designs. The $5195 Acer 1100 and the $4290 Micro 1 386+ both fall in this group of lower-priced, powerful 80386 personal computers.



The Micro 1 386+ (left) and the Acer 1100 (right).

Memory Design

At first glance, all the new 80386 computers have similar features. They typically provide 1 megabyte of standard RAM and use a 16-megahertz 80386. But within this specification, the designer has lots of room for trade-offs between price and system performance, particularly in memory-subsystem design. The machines under review use different memory designs.

The Acer 1100 uses an expensive but simple design: fast-access, fast-response RAM. The Acer 1100 comes standard with 1 megabyte of RAM on the motherboard. RAM is expandable to 8 megabytes with a single, proprietary 32-bit expansion slot; expanding RAM beyond 8 megabytes requires an AT-compatible 16-bit memory board, with slower access times and transfer rates.

The Acer's system RAM is mostly zero-wait-state, 100-nanosecond dynamic RAM. As a result, memory accesses by the microprocessor run unimpeded, no matter how the RAM is being used or what order memory locations are accessed. The Acer's memory system runs processor-bound programs about 5 to 6 percent faster than the Compaq Deskpro 386 and over 20 percent faster than the Micro 1 386+.

The Micro 1 386+ is designed around the 80386 motherboard manufactured by Intel. As a result, the options open to the Micro 1's designers are extremely limited. The unit I reviewed had 2½ megabytes of installed RAM: 512K bytes was standard on the motherboard, and 2 megabytes resided on a memory board in one of the system's two 32-bit expansion slots. The other 32-bit slot can hold another 2-megabyte board; thus, you can expand the system to 4½ megabytes of fast 32-bit RAM before you have to use slower 16-bit boards.

The RAM system in the Micro 1 uses 120-ns dynamic RAM with either one or three wait states depending on the type of memory access involved. The system uses an interleaved memory design: successive 32-bit double words are stored in alternate banks of RAM, and programs that access memory sequentially read first from one bank and then from the other. This type of memory access runs with one wait state. However, if the application reads two successive 32-bit quantities from the same bank of RAM, three wait states must be inserted. The Compaq Deskpro 386 uses a similar memory design with faster RAM, and the Micro 1's performance averages about 15 percent slower than the Deskpro 386. [Editor's note: *See "The Compaq Deskpro 386" product preview in the November 1986 BYTE.*]

Disk Systems

The other major contributor to the performance of an 80386 system is its hard disk subsystem. Both of the machines that I reviewed used Western Digital disk controllers with 40-megabyte MiniScribe hard disk drives, and both showed distinct performance improvements over the Deskpro 386.

The effective data-transfer rates (a measure of the overall throughput of the disk system), as measured by Core International's CORETEST utility, were 161.8K bytes per second for the Micro 1 386+ and 253.7K bytes per second for the Acer 1100, compared to the Deskpro's 235.3K bytes per second for its 40-megabyte hard disk. Although disk access times are a more popular means of measuring disk speed, they measure only a small part of the disk system and can be

continued

Ed McNierney is a principle engineer at Lotus Development Corp. You can contact him at 53 Hubbard Ave., Cambridge, MA 02140, or on BIX as "mced."

misleading. Both of these machines provide visibly faster disk access than the Deskpro 386, but the access times of their disk drives are actually slower than the Deskpro's (33.2 milliseconds for the Micro 1 and 27.7 ms for the Acer, as compared to Compaq's 22.2 ms).

To measure the effect of combined disk and memory performance in a real-world application typical for an 80386 machine, I installed Borland's Turbo C 1.0 on each machine and built the sample MicroCalc spreadsheet provided with the Turbo C package. This spreadsheet, provided in source-code form, represents over 7700 lines of C code. I compiled the program and then linked it with the Turbo C libraries. The compilation and linking was under the control of a make file and was run inside Turbo C's interactive editing environment. The results of this test surprised me: The Deskpro 386 took 71 seconds to recompile and relink the entire spreadsheet program, while the Micro 1 took 31 seconds, and the Acer 1100 only 24 seconds.

Acer 1100

The Acer 1100 system that I reviewed was the Model 40E, with a system unit, keyboard, EGA display adapter, monitor, 1.2-megabyte floppy disk drive, 40-megabyte hard disk drive, 1 megabyte of system memory, serial port, parallel port, a socket for an 80387 coprocessor, and MS-DOS version 3.2 with GW-BASIC. Eight expansion slots are present: two 8-bit slots, five AT-style 16-bit slots, and one proprietary 32-bit slot for memory expansion. The EGA board was ATI Technology's EGA Wonder with BIOS version 1.07, and the system unit used the Award BIOS 386 version 1.00. The Acer 1100 is certified as FCC Class B, suitable for home or office use.

The keyboard layout matches the IBM enhanced AT keyboard. The keyboard has a very comfortable, solid feel with a mechanical click that is reassuring but a little on the loud side.

The Acer 1100 comes with a system-environment utility that lets you change the speed of the CPU and the manner in which the BIOS is used. The default CPU speed is 16 MHz; a switch slows it down to 6 MHz when accessing the floppy disk drive. This automatic switching lets you use many copy-protected programs that require the use of a key disk.

Although the documentation suggested slowing the system to 6 MHz before running Lotus 1-2-3 version 2, I encountered no problem when I ran the program at 16 MHz. I installed it on the hard disk and uninstalled it at the standard system speed. Such flexibility is an important feature, especially since you set the system speed with a program rather than

Acer 1100 (Model 40E)

Company
Acer Technologies Corp.
401 Charcot Ave.
San Jose, California 95131
(408) 922-0333

Components
Processor: 16-MHz Intel 80386; socket for Intel 80387 coprocessor
Memory: 1-megabyte zero-wait-state RAM on motherboard, expandable to 16 megabytes
Mass storage: 1.2-megabyte 5¼-inch half-height floppy disk drive; 40-megabyte 28-ms-access hard disk drive; expandable to five half-height drives
Display: EGA-compatible display adapter; 14-inch color monitor
Keyboard: 101-key enhanced keyboard
I/O interfaces: Two serial and one parallel port; five AT-compatible 16-bit expansion slots; two PC-compatible 8-bit expansion slots; one proprietary 32-bit expansion slot
Other: Real-time clock/calendar with battery; 196-W power supply; Award 386 BIOS; selectable processor speeds; front-panel system-reset button; 12-month warranty (4-month on-site)

Size
6¼ by 20¾ by 16½ inches; 58 pounds (system unit and keyboard)

Software
MS-DOS 3.2; GW-BASIC 3.2; installation and setup utilities

Options
80-megabyte hard disk drive: $400
130-megabyte hard disk drive: $2,300
14-inch amber monochrome monitor ($450 off system price)
32-bit 2-megabyte memory card: $995
32-bit 4-megabyte memory card: $1495

Documentation
MS-DOS manual; GW-BASIC manual; *Acer 1100 User's Guide*

Price
$5195

Inquiry 884.

Micro 1 386+

Company
Micro 1
557 Howard St.
San Francisco, CA 94105
(415) 974-5439

Components
Processor: Intel 80386 at 16 MHz; socket for Intel 80387 coprocessor
Memory: 512K-byte one- or three-wait-state RAM on motherboard; 2-megabyte memory expansion installed, expandable to 16 megabytes
Mass storage: 1.2-megabyte 5¼-inch half-height floppy disk drive; 40-megabyte 38-ms-access hard disk drive
Display: Hercules-compatible display adapter; 12-inch monochrome monitor
Keyboard: 101-key modified enhanced keyboard
I/O interfaces: One serial port with external connector; one parallel port with external connector; four AT-compatible 16-bit expansion slots; two PC-compatible 8-bit expansion slots; two proprietary 32-bit expansion slots
Other: Real-time clock/calendar with battery; 220-W power supply; Phoenix 386 BIOS; keyboard-selectable processor speeds

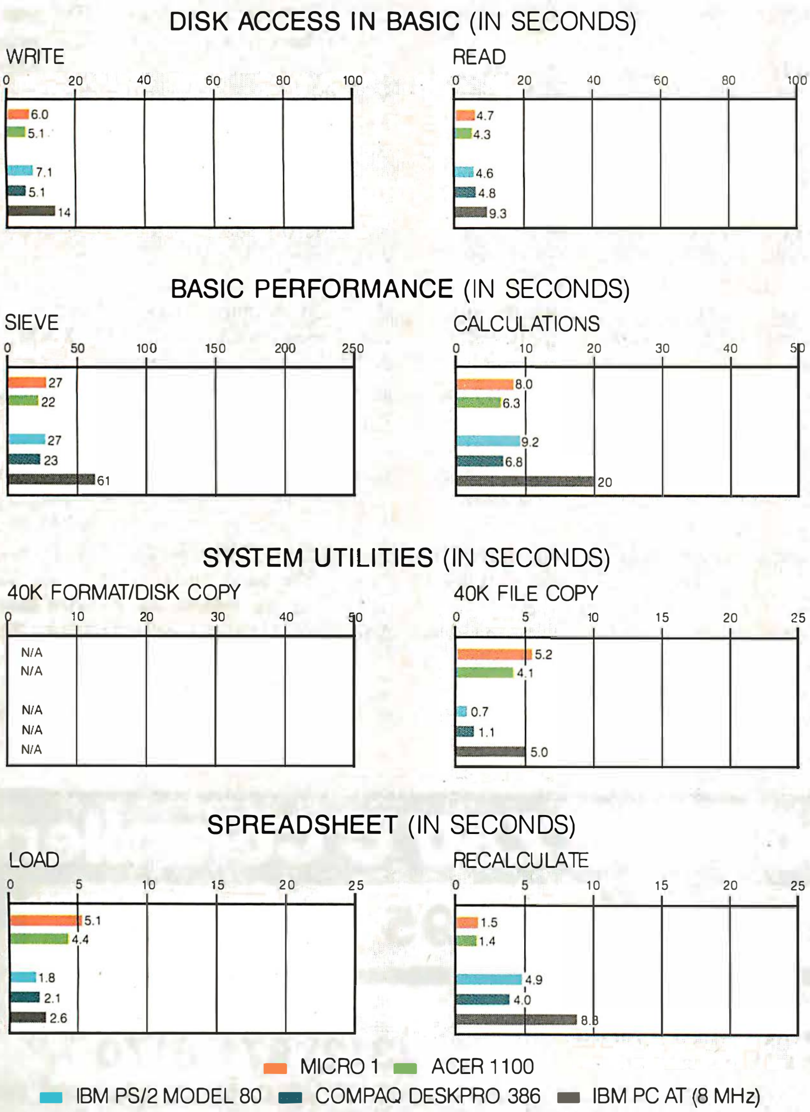
Size
6½ by 21 by 16½ inches

Software
MS-DOS 3.3; processor-speed test software

Documentation
Photocopied *Intel OEM System-Board Adaptation Reference*

Price
$4290
[Editor's note: *The Micro 1 386+ can be configured with the graphics board or disk drive of your choice. Prices vary according to configuration.*]

Inquiry 885.



	Micro 1	Acer	PS/2 80 80387	Compaq 386 80387	IBM PC AT 80287
Dhrystone*	3272	3978	3626	3748	1590
Fibonacci	64.59	52.34	57.26	53.11	126.22
Float	40.39	34.32	1.62	1.43	10.98
Savage	354.21	292.31	9.49	8.95	37.30
Sieve	6.78	5.66	6.45	5.98	24.60
Sort	8.35	7.96	7.74	5.58	43.17

(*Higher figures denote faster performance.)

The Disk Access benchmarks write and then read a 64K-byte sequential text file to a hard disk. Sieve runs one iteration of the Sieve of Eratosthenes. Calculations performs 10,000 multiplication and division operations. The 40K Format/Disk Copy benchmark is not performed on computers with only one floppy disk drive. The 40K File Copy benchmark copies a 40K-byte file on the hard disk. The Spreadsheet tests load and recalculate a 100-row by 25-column Multiplan (1.10) spreadsheet. All BASIC benchmark programs were run with MS-DOS 3.10 and GW-BASIC 3.0. The table contains the results of C language benchmarks (see "A Closer Look" by Richard Grehan in the September 1987 BYTE). All times are in seconds, except for the Dhrystone, which is in Dhrystones per second.

with a keyboard command. In many cases, if you have to slow the system down to get an application running, there is then no way to speed the system up again from within that application.

You can change the CPU speed to 12, 10, 8, 6, or even 4.77 MHz to accommodate even the most speed-dependent programs. You can also switch the BIOS access method between RAM and ROM access, with a default setting selected by a DIP switch on the motherboard. The system reserves 128K bytes of memory for the BIOS, and, at power-up, the contents of the ROM BIOS are copied to this RAM area. From then on, all BIOS accesses run through the faster 32-bit RAM instead of through the ROM. However, some applications may have difficulty using the relocated BIOS and may require switching to the ROM version at run time.

Unfortunately, there is no way to disable the RAM cache entirely to use the 128K bytes of reserved memory for some other purpose. In fact, this memory is effectively hidden from the system: When 1024K bytes is installed, the RAM self-test at power-up counts up to only 896K bytes. This count is confusing, and it should be better documented so users won't assume that some of their RAM is malfunctioning.

The motherboard switches that select between RAM and ROM BIOS also allow you to either select the remaining 256K bytes of system RAM as extended memory addressed beyond 1 megabyte or to disable it entirely in case of conflict with other extended-memory boards. (The 1 megabyte of system memory is divided into 640K bytes, the 128K-byte BIOS area, and a 256K-byte remainder.) If you configure it as extended memory, one of two supplied system utilities can be used to set up that memory as either a RAM disk or Expanded Memory Specification (EMS) memory. Should a new 256K-byte ROM BIOS be introduced, you can set a switch to convert from 128K bytes to 256K bytes and allow the system to accept a ROM upgrade.

In addition, a switch lets you slow down the system by inserting one wait state into all RAM accesses. Although not useful for the standard system, this feature lets you use slower 16-bit RAM expansion boards. Such a compatibility consideration is commendable, but users would be well advised to buy only new 32-bit RAM boards for any 80386 system. Anything less severely cripples the performance of the system.

Acer 1100 Compatibility

The Acer 1100 showed admirable IBM PC compatibility, running Lotus 1-2-3

continued

The CMOS battery backup system used in the Micro 1 is somewhat unusual; it is driven by four AA batteries instead of the usual monolithic package.

version 2.0, SideKick version 1.56A, Microsoft Word version 3.0, the Microsoft Bus Mouse version 5.03, Microsoft Windows version 1.03, and a number of editors and software development tools. The only problem I encountered was with an older version of DESQview (version 1.02), which would not recognize the Alt key. Since DESQview uses the Alt key as the DESQview system-request key, this limitation rendered the package useless.

The Acer 1100 differs from other machines in the length of the standard system beep tone. This variation is not an important compatibility issue, and it would be insignificant except that the beep lasts for over 1 second. That's more than long enough to get the point across; it's also long enough to irritate the user. If you get ahead of the keyboard buffer and hit five keys quickly before realizing it, you have to suffer through nearly 6 seconds of steady beep before you can continue. I hope Acer abbreviates the beep in future versions of the machine.

Acer 1100 Documentation

The Acer 1100's documentation, both in reference manuals and in on-line help, is by far its weakest feature. All the information is there, and Acer supplies all the needed utilities, but the information is hard to find and the utilities not very easy to use. Also, although the documentation contains relatively few grammatical errors, its non-English origin is apparent. Many of the "explanations" consist of the same sentence repeated three times, changing the word order each time. The result is often confusing, especially for a novice trying to set up the system.

The errors range from puzzling (the hard disk drive installation aid tells you that the disk can be divided into two to four partitions, but it never asks how many partitions you would like), to amusing (at boot time, the EMS driver prints its "Reversion" number, and the glossary in the reference manual explains that the 80386 in the Acer 1100 runs at 16,000 hertz). A technically experienced PC user should have no real problems with this, but I recommend that novices have a dealer or a friend set up the system for them.

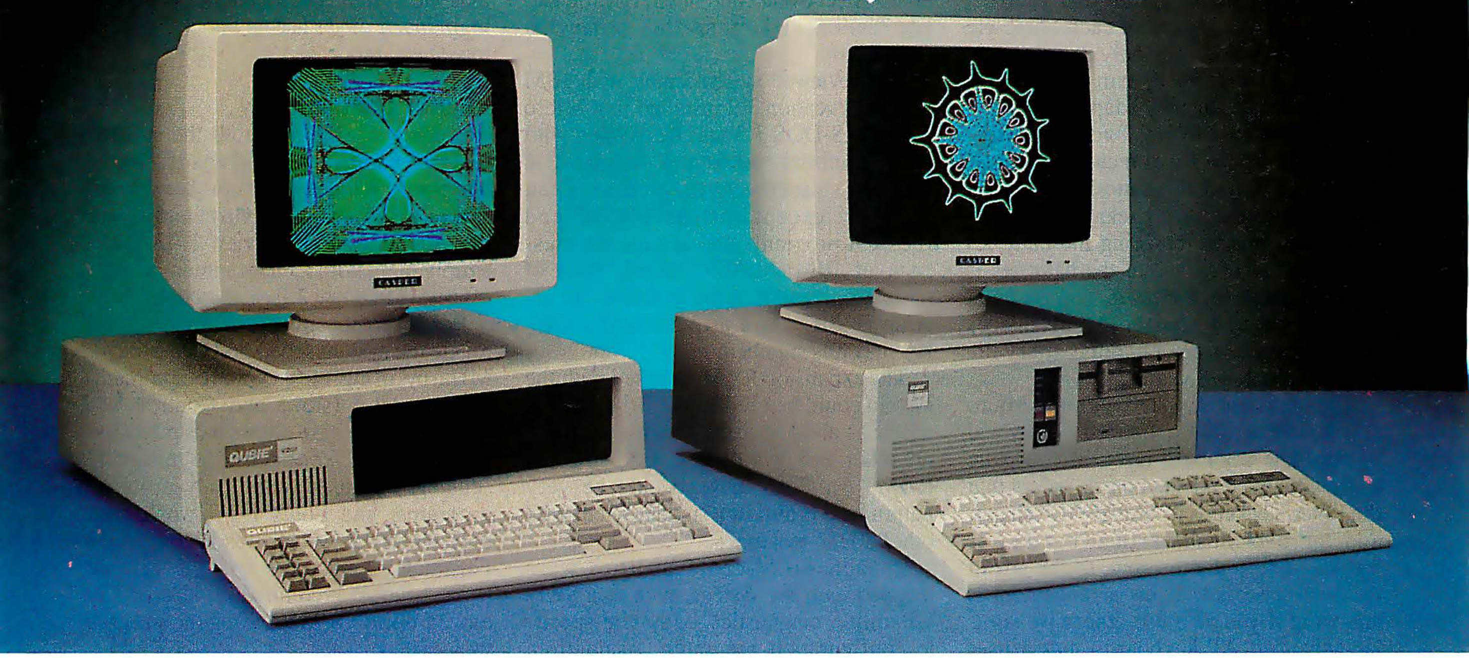
Micro 1 386+

The Micro 1 386+ system that I reviewed came installed with a 1.2-megabyte floppy disk drive, a 40-megabyte hard disk drive, 512K bytes of system-board RAM and 2 megabytes of expansion RAM, an 80387 socket, a monochrome display and Hercules-compatible adapter, and eight expansion slots (two 8-bit, four 16-bit, and two proprietary 32-bit slots for memory expansion). One of the 32-bit memory slots was occupied by the 2-megabyte RAM expansion board. The ROM BIOS was version 0.99c by Phoenix Technologies. The hard disk device driver supplied with the system was Golden Bow's Vfeature Deluxe version 2.36. This driver lets you use the entire 40-megabyte disk as a single DOS volume.

Although the Micro 1's Intel mother-

continued

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board has standard serial and parallel ports, no cables were provided for these connectors. Micro 1 claims that a full set of cables is bundled with each complete system purchased. The only port connector supplied with my system was the parallel port on the display adapter.

The CMOS battery backup system used in the Micro 1 is somewhat unusual; it is driven by four AA batteries instead of the usual monolithic package. This arrangement makes replacing the batteries a little easier. The life of the batteries is an open question, however, and frequent replacement may obviate the advantages of this system. Micro 1 claims battery life is approximately 3 years.

The keyboard supplied with the Micro 1 is a sort of IBM enhanced AT hybrid model. The keyboard layout is the same as the enhanced AT keyboard, except that the Enter key keeps its old AT "L" shape, and the backslash/vertical bar key is moved back to the top row, to the left of the Backspace key. This arrangement is annoying if you also use otherwise similar enhanced AT keyboards, but a user could grow as accustomed to it as to any other keyboard.

The keyboard lets you switch the positions of the left Control and Caps Lock keys. Since the Caps Lock key is wider, duplicate keytops are supplied. The keyboard is very quiet and has very little tactile feedback; I found this somewhat unpleasant.

The reviewed system came with IBM PC-DOS version 3.2 installed, but Micro 1 says MS-DOS 3.3 will be shipped with each machine. Although version 3.2 won't be shipped with the product, it ran properly except for the BASIC and BASICA programs that assume the presence of IBM's BASIC ROM; both of these programs hung the machine. No generic BASIC (such as Microsoft's GW-BASIC) was supplied.

The expansion RAM supplied with the system could be used by the IBM VDISK utility as a RAM disk; Micro 1 supplied no other utility software for using the RAM. An EMS driver would be very helpful and is almost a standard item with other 80386 machines.

In fact, no Micro 1 utilities were shipped with the system, such as a SETUP utility, diagnostics, or system-specific configuration programs. Aside from PC-DOS and the Vfeature Deluxe disk device driver, the only other software bundled with the system was a version of Landmark's SPEED utility. This utility provided an attractive screen display that served little purpose except to confirm that the system ran at about 16 MHz in high-speed mode and at about 6 MHz in low-speed mode.

Micro 1 Compatibility

The Micro 1 386+ ran all the software tested (SideKick, Microsoft Word, Microsoft Windows, several editors, and several software development tools), with the exception of DESQview 1.02, which simply hung with a blank screen. Micro 1 offers DESQview 2.0 as an option.

For speed-sensitive programs, you can toggle the system speed between 6 and 16 MHz by using the keyboard commands Control-Alt-1 (slow) and Control-Alt-2 (fast); each of these commands provides a beep tone as feedback. No automatic sensing was used with copy-protected programs, and Lotus 1-2-3 would start only when the system was in low speed. Fortunately, since the speed is switched by a keyboard command, it could be moved up to 16 MHz after the program was started.

The Hercules compatibility of the monochrome display seemed complete, but the graphics-mode display was very

continued

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noisy and rippled so much it was useless. The text-mode display was comfortable to use with the amber monitor supplied, but the display adapter should not be considered for use in Hercules graphics mode. [Editor's note: *Micro 1 acknowledged that the graphics card shipped with systems prior to early July had a high failure rate. Micro 1 replaces faulty graphics cards on request. In the interim, the Hercules Fullsave utility clears up problems with a defective card.*]

Micro 1 Documentation

Documentation for the Micro 1 386+ was virtually nonexistent. The machine was shipped with a MiniScribe reference manual describing the hard disk system in extreme detail, but since the hard disk drive comes installed, the reference manual is not needed at all. The system documentation consists of only a photocopied reference manual from Intel intended for OEMs developing systems around Intel's motherboard. With both documentation and utility software lacking, it is not clear how a user would set up and install this system.

The Verdict

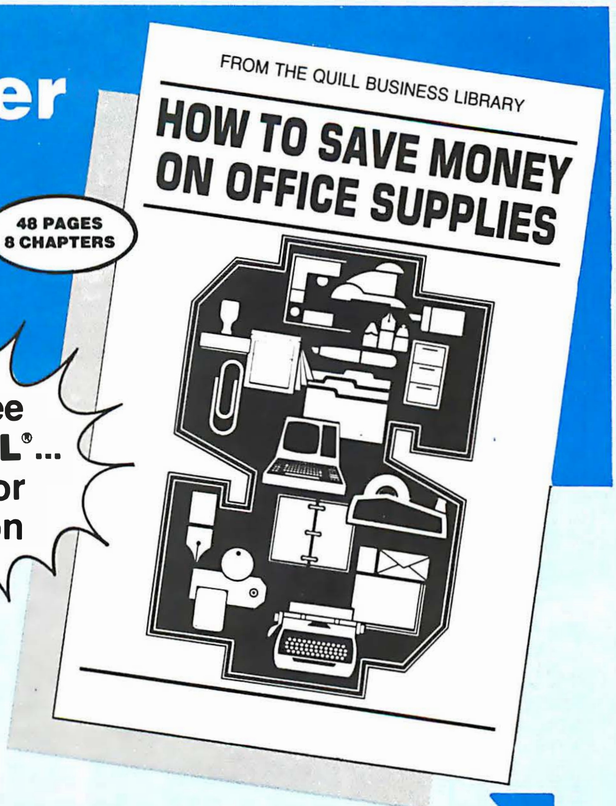
The Acer 1100 is a very impressive computer, with a design that clearly emphasizes performance. The benchmark results show it to be faster than a Compaq Deskpro 386 at a significantly lower price. The machine's chief weakness is its documentation, but the power of the system makes the effort to set it up worthwhile.

The Micro 1 is a medium-performance 80386 machine with a slow RAM system and a fast hard disk system. My overall impression is that it is not quite done, with vital documentation and utility software missing. The Micro 1 386+ may be a good value for someone who is more interested in running 80386-specific software than in maximum performance, but unless the system can be bought fully set up and installed with the desired software, it may not be worth the effort.

A final note on compatibility: The Micro 1 386+ will boot OS/2 but the Acer 1100 will not. These two machines take divergent paths on several points of 80386 system design. These paths lead, on the one hand, to a powerful, high-performance machine with only a few quirks (the Acer 1100), and on the other, to a stock machine built around a stock motherboard, where the extra effort required to produce a polished product was not spent (the Micro 1 386+). I highly recommend the Acer 1100 (especially in a multiunit purchase where one experienced person sets up the machines for the users), but the Micro 1 386+ needs some more work before it can merit serious consideration as an 80386 solution. ■

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80286 Accelerators

Raymond GA Cote

Speed improvements range from 0 to 92 percent, depending on the application

The accelerator boards reviewed in this article offer owners of IBM PC and XT compatibles the possibility of getting AT-class performance simply by adding a plug-in board to their existing computer. The boards all cost $1200 or less and use an 80286 processor ranging in speed from 7.2 to 12 megahertz. Possible improvements compared to a standard 4.77-MHz PC XT range from a 92 percent reduction in a database-indexing test to a slight degradation using a disk-intensive test—illustrating that the benefit of an accelerator depends on how you use your computer.

These products fall into three categories: replacement, switcher, and multiprocessor boards.

Replacement boards give the 80286 control of the computer; the 8088 is removed. Cards I reviewed in this category are the Everex Expediter, Mountain Computer RaceCard 286, and the Seattle Telecom & Data PC286-12.5 and PC286-10. While these cards are installed, your computer is limited to 80286 operation.

Switcher cards are similar to replacement cards, except that the 8088 processor is left in the system (albeit moved from the motherboard to the add-on card). Through hardware or software commands, you can switch back and forth between processors. The exact method of switching processors varies with the different products. I reviewed five switcher boards: Micro 1 286, MicroWay's FastCACHE-286-9 and -286-12, Orchid Technology's TinyTurbo-286, and Peripheral Marketing's PMI 80286.

Multiprocessor cards are essentially self-contained computers that operate independently of your 8088, opening up the promise of limited parallel processing. You simply plug these boards into the system as you would a graphics adapter or serial card; the 8088 stays in its socket on the motherboard. The only two multiprocessor boards I reviewed are the Applied Reasoning PC-elevATor and the Orchid Technology PC Turbo-286e.

Questions of Compatibility

Running a PC or XT compatible at a clock rate higher than 4.77 MHz can cause compatibility problems when you attempt to use timing-sensitive software. Many copy-protection schemes (among them, the scheme used in early versions of Lotus 1-2-3) won't work properly, so you are unable to run the protected software in the accelerated system.

Game programs (Flight Simulator is an example) geared to a 4.77-MHz clock may also operate erratically in a souped-up system. To get around this problem, all but the RaceCard 286 provide a hardware or software speed switch to slow down the 80286 to 4.77 MHz.

That may not be the end of the compatibility problem, however. Some programs absolutely require an 8088 processor to execute properly, due to the fact that the 80286 executes some instructions faster than does the 8088. The ability to switch back to 8088 operation is the only resort in these cases. With replacement cards, your only option is to remove the accelerator card and reinstall the 8088 chip.

All the switcher cards provide an external switch for switching from 8088 to 80286 mode. Unfortunately, on all the systems except the Micro 1, this also means these systems must be rebooted (reset or powered off and on again). The Micro 1 is unique in allowing programs to switch back and forth between 80286 and 8088 modes during program execution, by means of a hot-key combination. A DOS command is also available.

With multiprocessor boards, you also switch processors via a DOS command. Since the multiprocessor has its own memory, switching processors also entails switching the memory context, making it possible to have two independent programs operating simultaneously. The multiprocessor and main processor share a 64K-byte address space, which can be used for interprocess communication if the software is written properly to obey some conventions spelled out in the PC Turbo-286e and PC-elevATor manuals.

Memory Considerations

The boards provide one of two memory types: general-purpose RAM or dedicated cache. Any general-purpose RAM provided on the replacement and switcher boards exists in the same memory space as your system's previously installed RAM. However, the access time of the accelerator boards is typically 100 to 120 nanoseconds, as opposed to 150 ns for the standard memory in a PC- or XT-compatible computer.

General-purpose RAM provided on the multiprocessor boards is independent of your system's RAM. Access time of the PC Turbo-286e is 120 ns; the PC-elevATor comes with 150-ns memory. Dedicated cache memory (described below) exists independent of system RAM, as well. Table 1 indicates the type of memory on each board and the speed and amount of standard and optional memory included in that type.

All boards are compatible with EMS and EEMS software and hardware; the PC-elevATor comes with EMS software.

Caching

Caching is the process of moving often-used (or recently used) information from

continued

Raymond GA Cote is a consultant to the educational/service robot industry. He can be contacted at Ceargs, P.O. Box 458, Peterborough, NH 03458.

relatively slow memory devices to relatively fast memory devices. Caching is done on the operating-system level, so the application program need not be concerned with the data's physical location. Caching can be done with respect to memory or to disk accesses.

Memory caching is provided by the TinyTurbo-286, PMI 80286, RaceCard 286, MicroWay 286-9 and 286-12, and Micro 1. Disk caching is possible with all cards through software (provided with the card or available commercially). Only the PC Turbo-286e establishes a hardware disk cache, which is explained below.

Memory caching doesn't require a great deal of actual RAM. As you can see

Table 1: *Features of the 11 accelerator boards grouped according to type.*

Manufacturer	**Everex**	**Mountain Computer**	**STD**	**STD**	**Micro 1**	**MicroWay**	**MicroWay**	**Orchid**
Model	**Expediter Turbo Card**	**RaceCard 286**	**PC286-10**	**PC286-12.5**		**FastCACHE-286-9**	**FastCACHE-286-12**	**TinyTurbo-286**
Price	$399	$495	$995	$995	$500	$399	$599	$445
Type	R	R	R	R	S	S	S	S
Processor speed (MHz)	8	8	10	12	8	9	12	7.2
Optional 80287 speed (MHz)	8	8	8	10	8	10	10	8
Board size	Full	1/2	Full	Full	1/2	1/2	1/2	1/2
Power drain (watts)	8 empty 9 w/ 640K	7.0	12.5	12.5	7.5	7	7	7.0
RAM:								
Standard (K)	0	-	640	640	-	-	-	-
Optional (K)	256	-	0	0	-	-	-	-
Speed (ns)	120	-	100	100	-	-	-	-
Cache RAM:								
Size (K)	-	8	-	-	8	8	8	8
Type	-	Static	-	-	Static	Static	Static	Static
Cache speed (ns)	-	NA	-	-	50	55	55	45
Clock switch:								
External toggle	No	No	No	No	No	Yes	Yes	Yes
DOS command	Yes	No	Yes	Yes	Yes	No	No	No
Hot key	No	No	No	No	Yes	No	No	No
Processor switch	-	-	-	-	DOS,HK	HW,CB	HW,CB	HW,CB
Cache switch	-	-	-	-	Yes	HW,OK	HW,OK	None
EGA-compatible	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Software:								
Installation	Yes	No	Yes	Yes	Yes	No	No	No
Disk caching	No	No	No	No	No	Yes	Yes	No
Testing	Yes	No	Yes	Yes	Yes	Yes	Yes	No
Print spool	No	No	No	No	No	Yes	Yes	No
RAM disk	No	No	No	No	No	Yes	Yes	No
User support:								
Documentation	53-pg. UM	24-pg. UM	25-pg. UM	25-pg. UM	50-pg. UM	17-pg. UM	17-pg. UM	14-pg. UM
Warranty	1 yr.	1 yr.	90 days	90 days	3 yr.	1 yr.	1 yr.	1 yr. 2 yr. reg.

Board type: S=switcher, R=replacement, M=multiprocessor; Processor switch: HW=hardware; CB=cold boot required; OK=no reboot required; HK=change with hot key; DOS=change with DOS command; ↑=8088 to 80286; ↓=80286 to 8088. Documentation: UM=user's manual; PM=programmer's manual. Warranty reg.=for registered users. Price is for the standard board without 80287 and without optional memory.

from table 1, the memory-caching cards contain just 8K bytes of on-board cache. Note also, however, that the access time of the memory cache is typically 50 ns, as opposed to the 150-ns memory used in ordinary RAMs. The on-board cache memory is organized into 16-bit data words.

When the processor on an accelerator card using memory caching requests information (either program code or data) from a particular memory location, the caching mechanism first checks to see if the information is already in the high-speed cache. If it is there, it is rapidly returned to the processor. If it is not there, it is read from the relatively slow main memory.

All the memory-caching cards I tested, except for the TinyTurbo-286, provide the ability to turn memory caching on and off. This feature is necessary since caching can occasionally interfere with programs or hardware. For instance, memory-test routines may end up testing the cache memory over and over again and not testing the main system memory properly.

Another potential problem with memory caching is with EMS and EEMS memory cards that use bank-switched memory access; the memory management software may change the current memory bank without telling the cache, so that the cache contents aren't really synchronized with the current memory block.

In disk caching, a block of main memory is reserved for the disk cache; the processor determines if the information requested from disk is already in the cache or not. Although this process consumes some of the processor's time, it is still much faster than having to wait for a disk access for each and every read. Unlike memory caching, disk caching tends to be implemented totally in software. The nonmemory-caching boards all provide on-board, general-purpose memory, some of which can be used for disk caching.

The benchmarks reported in table 2 were executed without any of the software disk-caching programs delivered with these boards. My reasoning was that this form of disk caching is a software issue, and I wanted to test the hardware throughput of the systems. Even if caching software is not included with a system, you can use one of the many commercial products on the market.

The PC Turbo-286e board, however, uses a hardware approach to disk caching: The 8088 performs all I/O functions. Since one of these functions involves reading and writing the disk, and since there is usually a fair bit of memory on the main system (up to 640K bytes on the system I used that normally isn't doing anything), the PC Turbo-286e treats the PC XT motherboard as an enormous disk cache.

This makes the PC Turbo-286e blindingly fast for some of the disk-related speed tests. The *load 40K text file* benchmark is an excellent case in point. The first time the file was read, it actually had to be loaded from the disk since the information had never been read before. The 2.7-second read time is typical for most of the boards. However, the second time the exact same file was read, the bench-

continued

PMI 80286	Applied Reasoning PC-elevATor	Orchid PC Turbo-286e
$295	$995	$1195
S	M	M
8	8	10
8	10	10
3/4	Full	Full
6.3	10.0	13
-	1000	1000
-	1000	1000
-	150	120
8	-	-
Static	-	-
45	-	-
Yes	No	No
No	Yes	Yes
No	No	No
I=HW,CB t=HW,OK	DOS	DOS
HW,OK	-	-
Yes	No	No
No	Yes	Yes
No	Yes	Yes
No	No	No
No	Yes	Yes
No	Yes	Yes
30-pg. UM	90-pg. UM	90-pg. UM 50-pg. PM
1 yr.	1 yr.	1 yr. 2 yr. reg.

Accelerator Manufacturers

Applied Reasoning Corp.
765 Concord Ave.
Cambridge, MA 02138
(617) 492-0700
Inquiry 905.

Everex Systems Inc.
48431 Milmont Dr.
Fremont, CA 94538
(415) 683-2100
Inquiry 906.

Micro 1
557 Howard St.
San Francisco, CA 94103
(415) 974-5439
Inquiry 907.

MicroWay
P.O. Box 79
Kingston, MA 02364
(617) 746-7341
Inquiry 908.

Mountain Computer Inc.
360 East Pueblo Rd.
Scotts Valley, CA 95066
(408) 438-6650
Inquiry 909.

Orchid Technology
45365 Northport Loop W
Fremont, CA 94538
(415) 683-0300
Inquiry 910.

Peripheral Marketing Inc.
7825 East Evans Rd., #500
Scottsdale, AZ 85260
(602) 483-7983
Inquiry 911.

Seattle Telecom & Data Inc.
12777 134th Court NE
Suite 205
Redmond, WA 98052-2429
(206) 820-1873
Inquiry 912.

mark returned a time of 0.8 second: The file was now totally within the hardware disk cache, so the disk was not even accessed during this second benchmark run.

Floating-Point Chips

Many performance-conscious users have bought 8087 numeric coprocessor chips for their PC- and XT-compatible systems, at a typical cost of around $125. Unfortunately, the replacement and switcher cards (with one exception) require you to remove the 8087 from the motherboard, regardless of whether you plan to install an 80287 on the accelerator board. (All the accelerator boards include a slot for the 80287 numeric coprocessor chip.)

The Micro 1 286 accelerator lets you leave your original 8087 coprocessor on the main motherboard and also have an 80287 numeric coprocessor on the accelerator card. The 8087 is accessible when operating in 8088 mode, and the 80287 is accessible when operating in 80286 mode. The Micro 1 documentation does provide one note of warning, however: Be careful of switching between the 8088 and 80286 modes when you have a numeric coprocessor available in one mode but not the other, lest the software attempt to send instructions to a nonexistent chip.

Multiprocessor boards, because they operate independently of the 8088 processor, do not require the removal of an installed 8087 chip.

Benchmark Results

I tested the boards in a 4.77-MHz IBM PC XT with 256K bytes of RAM on the motherboard and an additional 384K bytes on a memory-expansion board. The system also included a Seagate 20-megabyte hard disk drive and a Paradise Systems AutoSwitch EGA Card driving an NEC MultiSync color monitor. All the accelerator cards were equipped with an 80287 coprocessor running at the speed stated in table 2, but only one of the benchmark tests, AutoCAD nozzle, exercised the coprocessor.

All BASIC benchmarks were performed using BASICA. The benchmarks executed are as follows (see table 2's footnotes for additional comments).

The first two tests involve writing and reading a 64K-byte sequential file onto a blank floppy disk. Since disk I/O speed is limited by the disk access time rather than by how fast the processor can read data from or write it to the disk ports, you

Table 2: *Byte benchmarks and system capabilities (all times are in seconds). The IBM PC XT baseline times for the AutoCAD nozzle benchmark are given with and without an 8087 numeric coprocessor.*

Manufacturer	Everex	Mountain Computer	STD	STD	Micro 1	MicroWay	MicroWay	Orchid	PMI
Model	Expediter Turbo Card	RaceCard 286	PC286-10	PC286-12.5		FastCACHE-286-9	FastCACHE-286-12	TinyTurbo-286	80286
Write 64K, floppy disk	51.6	51.3	49.0	27.8	51.1	51.0	29.2	51.4	52.1
Read 64K, floppy disk	36.0	23.4	35.0	22.8	35.8	35.1	22.9	31.0	36.8
Calculate	14.5	19.6	14.3	11.3	15.2	18.9	16.2	19.4	19.8
Sieve	48.5	64.2	47.8	37.3	48.3	62.5	53.7	64.0	67.1
Spreadsheet load	3.3	3.0	2.8	2.5	3.3	3.9	2.8	3.5	4.8
Spreadsheet recalculate	7.3	9.7	7.9	6.2	8.0	9.4	7.9	10.8	10.9
Load 40K text, hard disk file	1.9	2.1	1.2	1.0	2.0	2.4	2.3	2.8	3.0
Search 40K	1.2	1.8	1.2	1.1	1.2	2.1	1.8	1.8	1.9
Database index	121	137	86	83	130	148	133	166	176
Database count	852	345	873	630	770	350	337	830	931
AutoCAD nozzle	12.9	21.9	9.0	10.9	23.5	23.3	20.8	20.3	29.5

Write 64K and **Read 64K** are BASICA programs that write and read a 64K-byte sequential file to a newly formatted 360K-byte floppy disk.
Calculate is a BASICA program that performs 20,000 multipcations and 20,000 divisions in single precision.
Sieve is a BASICA program that performs one iteration of the Sieve of Eratosthenes.
Spreadsheet load loads a 25 by 100 spreadsheet from a floppy disk file into Multiplan.
Spreadsheet recalculate recalculates all values in the 25 by 100 spreadsheet.
Load 40K text file loads a hard disk text file into a word processor (I used the program Brief).
Search 40K text file finds the last word in the loaded text file, using Brief.
Database index indexes a 1.2-megabyte, 7000-name mailing list in dBASE III, creating a 64K-byte index file, using the hard disk.
Database count counts the number of entries in the indexed file, using the hard disk.
AutoCAD nozzle times the regeneration of the standard AutoCAD nozzle drawing.

(1) Time reflects the effect of the PC Turbo-286e's large hardware disk cache.
(2) Board tested failed to display dBASE III workscreen.
(3) Boards tested did not support EGA mode required by AutoCAD.

don't expect to see much of a difference between the XT baseline and the accelerator-equipped systems, except when a disk cache is operating, as in the case of the PC Turbo-286e.

In fact, accelerator systems tend to run a little slower than standard PC XT systems during disk I/O because the speeded-up boards are not synchronized with the bus; this is especially true during file reads, when the accelerator board must wait to synchronize up with the bus timing.

Floppy disk file reads with accelerator boards were comparable to the baseline times, except for the disk-caching PC Turbo-286e (22 percent faster), the PC286-10 (48 percent faster), and the FastCACHE-286-12 (46 percent faster). The faster (12-MHz) clock rate on these last two boards happens to make a good synchronization with the system bus timing.

Database indexing makes a good test throughput, since it requires heavy disk access coupled with in-memory computing.

Seven of the boards (TinyTurbo-286, PMI 80286, Expediter, PC-elevATor, PC286-10, FastCACHE-286-9, and Micro 1) are slower in floppy disk file reading than the baseline machine; times ranged from 31 percent to 55 percent slower than the baseline. In two cases (PC286-12.5 and FastCACHE-286-12), the timings happen to synchronize up quickly, giving these boards file-read times comparable to those of the baseline. The PC Turbo-286e's disk cache gives it the best time on file reads from floppy disk: 54 percent faster than the baseline.

The next four tests are calculation-intensive, and here we see a more uniform improvement. Using the total times for all four tests, the improvement ranges from 65 percent on the PMI 80286 to 82 percent on the PC Turbo-286e.

The next two tests give some indication of the value of the cards for word-processing applications. The XT baseline was slightly faster at loading a 40K-byte text file from hard disk than all the accelerator-equipped systems, except for the two STD boards, again because of the cards' lack of synchronization with the bus. The STD boards make bus requests in synchronization with bus availability.

The in-memory word search gave the advantage to the accelerator boards in every case, with an improvement ranging from 50 percent on the FastCACHE-286-9 to 76 percent on the PC Turbo-286e.

For another realistic application test, I used a random name-and-address database running under dBASE III Plus. The database was 1.2 megabytes long and consisted of 7000 names. I timed how long it took to index the mailing list. The generated index file was approximately 60K bytes long. As an index key, I used the first three letters in the *city* field.

This benchmark makes a good test of actual processor throughput, since it requires heavy disk access coupled with a fair bit of in-memory computing. Improvements ranged from 78 percent with

continued

Applied Reasoning PC-elevATor	Orchid PC Turbo-286e	IBM PC XT baseline
51.5	41.9	53.7
36.8	11.0	23.7
14.4	10.3	57.8
48.6	34.3	191.0
4.9	1.4	7.7
7.9	5.7	33.3
3.0	2.7 0.8(1)	1.6
1.4	1.0	4.2
(2)	65	831
(2)	224	1823
(3)	(3)	292 30 (w/ 8087)

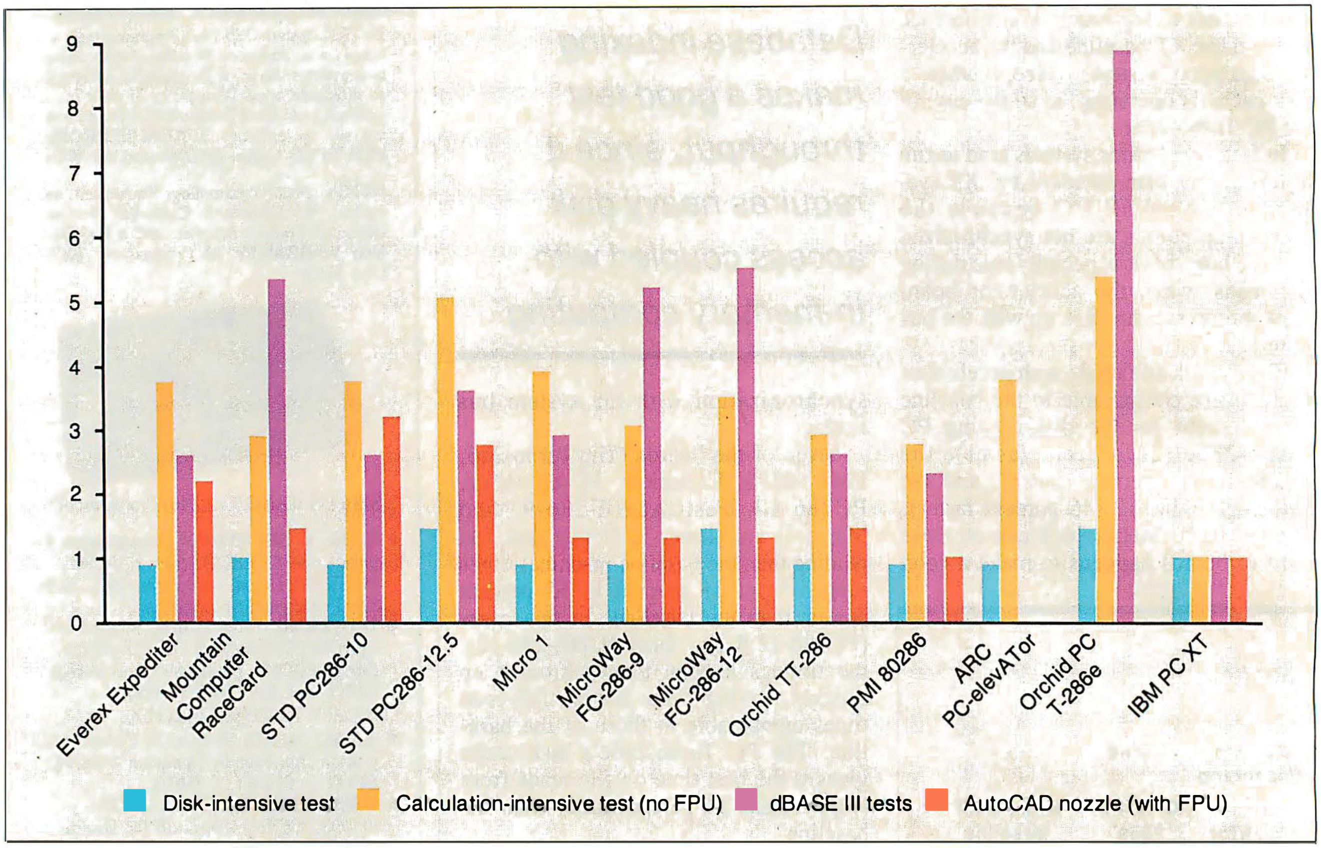


Figure 1: *Price/performance comparisons of the 11 boards:* ***(a)*** *disk-intensive operations with BASIC;* ***(b)*** *combined disk I/O and computation with the dBASE III tests;* ***(c)*** *computation without an 80287 or 8087, using the BASIC Sieve and Calculate tests;* ***(d)*** *computation with an 80287 or 8087, using the AutoCAD nozzle test.*

the PMI card to 92 percent with the PC Turbo-286e. The STD boards turned in an improvement of 90 percent, and all the other boards showed improvements of 80 percent to 85 percent.

After generating the index, I attached it to the data file and used the Count command to count all the entries in the file. This activity is very disk intensive since it requires the database to retrieve the next entry location from the index, seek to the entry's location in the file, load it, and then get the next index entry.

Most of the cards gave a 50 percent improvement over the XT baseline. Cards bettering that significantly were the PC Turbo-286e (88 percent), FastCACHE-286-12 (82 percent), FastCACHE-286-9 and RaceCard 286 (81 percent), and PC286-12.5 (65 percent).

The last benchmark exercised the optional floating-point coprocessor; for this one test, I installed an 80287 in each of the boards (clock rates are shown in table 1). I timed the systems on regenerating the standard AutoCAD nozzle drawing on an EGA display. For comparison purposes, I ran the benchmark for the baseline system with and without the optional 8087 numeric coprocessor.

Adding the 8087 to the baseline XT improved its time by 90 percent. Running the test on the 80287-equipped accelerated systems beat the 8087 time by values ranging from 22 percent (Micro 1 and the FastCACHE-286-9) to 30 percent (PC286-10). The PMI card showed only a negligible improvement over the 8087-equipped XT.

Accelerators versus ATs

The decision to purchase an accelerator board depends heavily on how you use your computer. If your primary application is computationally intensive with high disk activities (such as program development using compilers), a board like the PC Turbo-286e might be the solution, since it gives the best performance on the calculation tests and more robust database benchmarks.

On the other hand, many others provide significant improvements at lower costs. For example, all the cards managed to execute the dBASE III Plus index-construction benchmark four times faster than a standard IBM PC XT.

The obvious conclusion from the AutoCAD benchmark is that the cheapest way to get a big improvement in AutoCAD performance is to add an 8087 to your XT. If you already have one, you may think about adding an accelerator; but the improvement won't be tremendous.

Figure 1 ranks the cards according to price/performance in four categories: disk-intensive work in BASIC; combined disk and calculations, based on the dBASE III tests; calculations without the floating-point processor, based on the BASIC calculation benchmarks; and calculations with the floating-point processor.

One drawback of the two multiprocessor cards (PC Turbo-286e and PC-elevATor) is that neither supports an IBM EGA video card. Orchid Technology solves this problem by offering a dBus EGA card (list price $595) that plugs directly onto the PC Turbo-286e. However, this does limit your choice of EGA cards to exactly one.

Finally, it may simply be more attractive to replace your PC or PC XT with a PC AT. A PC AT will reduce your worries about compatibility and trying to make an XT act like an AT. Using an AT-class machine will also provide access to AT expansion slots that no accelerator card provides. Standard ATs also come with a faster hard disk that will dramatically improve operations like compilations and database indexing. ■



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Accelerator Boards

Ideas for improving PC performance from the BYTE Information Exchange

Curtis Franklin Jr.

The quest for computing speed began well before the microcomputer age. The major objective in hardware development has been more power for less money. As a way of satisfying the demands of rapid progress, the accelerator board has evolved as a means of computing faster without the expense and trouble of a whole new computer. In the messages below, some of the users of the BYTE Information Exchange (BIX) talk about what they want from accelerator boards (and accelerator-board manufacturers), why they use accelerator boards, and, in some cases, why they don't.

The first part of the section is a detailed look at what one programmer needs from accelerators and their manufacturers. He doesn't provide answers (for reasons detailed in the message), but does give a list of questions appropriate for many potential accelerator-board purchasers.

AN OPEN LETTER

ibm.pc/long.messages #138, from roedy (Roedy Green).

This is an open letter to the manufacturers of accelerator cards for the PC XT. I want to buy some, I have the money, I have the need, but for reasons I will explain, I have not yet done it.

This letter will later get quite technical, but first a note to your sales department:

Dear Sales Manager:
You might have been one of the companies I wrote to asking for technical information about your accelerator -- asking specific questions particularly pertaining to compatibility issues. What you sent me was an expensive color brochure devoted mainly to a huge picture of the beast with all kinds of esoteric information about megahertz, wait states, and static RAMs, *but not a peep* about compatibility or how the thing WORKS.

My reaction to this deafening silence was to presume the worst. "If they won't even talk about it, it probably only works with number-crunching programs that work strictly by the book and always use DOS to interface to the hardware. Oh well, not much use to me." I asked for reassurance. I got it. I was deeply reassured that the accelerator came in the form of a board with chips on it that I could stick in one of my expansion slots. However, I had reasonable faith that that would be the case even before I wrote.

Wasn't it Roedy Green who said "All the great programmers are paranoid?" The people who will buy your product or urge others to buy your product are programmers. They want and need massive reassurance that the thing will work before they buy or recommend it. Buying an accelerator is quite different from buying any other sort of peripheral. It will interact intimately with every piece of current and future hardware and software. If there are problems, expensive hardware and software may have to be replaced. There might not even be any alternatives.

Furthermore, because local dealers typically don't carry a range of accelerators to test-drive, buyers must order them by mail. Because installation involves prying chips out, there is always the possibility of damaging the accelerator and having the double insult of having it not work, and then having to pay for the damage caused in removing it.

So even a money-back guarantee is not sufficient inducement, unless it includes some assurance that the manufacturer will graciously accept a returned accelerator board, even if the pins are broken off, for a modest restocking and repair fee.

I'm in the same position as someone who owns an old car. Should I pay for repairs (buy an accelerator) or sell it now while it still has some value and buy a new one (AT clone). Your typical potential customer is thus very money-conscious. He may have a roomful of XTs, and does not want to junk them, but if the accelerators don't work in the long run, he will have made a very costly mistake, since he will eventually need to replace not only the machines, but also the XT-style peripheral cards bought after the accelerators.

I want to buy. I am willing to buy even if things are not perfect. All I want is some certainty that the expected likely problems are ones I can live with.

I hope those thoughts help you revise your sales literature and advertising. AND I am a secret speed freak. I spend my evenings polishing the inner assembler loops of the BBL Forth and Abundance database compilers. It would do my heart good to wave some impressive bangs-per-buck benchmarks under the noses of those rich guys with their 80386s. The Portable Computer Support Group's Flying Turtle ad appeals to that part of my psyche.

Now for the technical stuff:

I imagined I was given the task of designing an accelerator board. All sorts of potential problem areas sprang to mind. I would like you, the manufacturer, to answer the following questions for each problem area, and post the results on BIX.

1. Will it work? Would it melt anything if I tried it?

2. Will my computer work faster than it did before I installed the accelerator?

3. Will there be any flaky, intermittent problems if I try it?

continued

4. If it won't work, and I were willing to do anything to make it work -- including totally removing the accelerator, what would I have to do?

5. Why would it work? Briefly explain how your accelerator card is implemented so that it is clear why this would not be a problem.

Let us start with a simple common problem and work up to the tough, esoteric ones:

1. One of my turbo clones usually runs at 8 MHz rather than 4.77 MHz, as is normal, and it has a NEC V20 instead of an 8088. What will happen to the accelerator card if my main bus runs so fast?

2. All decently fast programs bypass DOS for screen I/O and write to the REGEN buffer directly. Since this buffer might not even be in the address space of the accelerator, how does the data get into the real REGEN buffer?

3. One of my machines has a no-name Taiwanese ROM BIOS that uses timing loops to control such things as disk formatting. If that BIOS code were run fast, disk formatting would not work. What do I do? Run slower when in BIOS? Replace the BIOS with a smart one? What about programs, such as games, that would run too fast? Can I slow them down?

4. Programs that write to the CGA REGEN buffer use various snow-removal techniques that depend on poking the 6845 CRT controller chip to ask it when horizontal retrace is about to occur, or to swap the two REGEN pages. If the REGEN buffer is in some way faked, it would seem the accelerator would be waiting needlessly to poke the fake REGEN, and the background task that copied from the fake REGEN to the real one might cause snow. In general, any direct poking of registers in the 6845 might not sync correctly with the background copying process.

5. I have invested, or may be planning to invest, a lot of money in the following software that I know plays some fancy tricks. Which of it will still work?

Microsoft Word	(trapping keyboard interrupts, screen paint)
Ventura Publisher	(expensive to replace)
Lotus 1-2-3 version 1	(copy-protected)
Fastback	(DMA, timing sensitivity)
CoreFast floppy backup	(uses proprietary disk format)
The Norton Utilities	(sound)
Cruise Control	(software cursor repeat)
Microsoft Flight Simulator	(general DOS bypasser)
ProComm modem program	(serial-port interrupts)
SuperKey	(gets its fingers in many pies)
XON/XOFF device driver	(chains into clock-tick interrupt)
LAN Server software	(might not be running under DOS)

6. I have invested, or am planning to invest, in the following hardware that might not work:

Mag Tape Backup	(DMA)
Periscope II debugger	(breakpoints, NMI from button)
Periscope III debugger	(monitors bus activity)
JLaser JRAM laser printer	(bus sensitivity/ addressability)
Logitech Mouse	(programs fielding own device interrupts)
Expanded RAM cards	(not in address space -- cache being fooled)
NOVIX coprocessor	(both want slave 8088 DOS to run a program)
LAN coprocessors	(shared RAM-fooling cache, whatever?)
High-res screen displays	(nonstandard REGENs)

7. If I use another coprocessor card, such as the Gateway LAN and X.25 cards, NOVIX Forth card, 68000 coprocessor or Western Digital X.25 card, or a multiport serial card that uses shared memory in the ROM region, how would a cache-type accelerator know that its cache was out of date when the other processor was changing that shared region? Are there other problems having such a coprocessor?

8. I am a programmer. I have total control of the code. Is there anything you could tell me about the caching mechanism that would help me write code that would really fly on your accelerator? What is the granularity and size of the cache? Are instruction fetches treated any differently than data fetches? If I could get spectacular results, everyone who uses my software would also want one of your accelerators.

9. When I write code to control exotic shared-memory devices, such as the Gateway LAN card, is there any way I can warn your accelerator to flush its cache because shared memory may have been changed by some other coprocessor? In other words, how do I warn it that its cache does not really contain the latest and greatest? If your processor does not use a cache, but has its own private address space, are there mechanisms that I can use to examine and change the shared RAM in the 8088's address space?

A final note to the sales people:

It will be a lot of work for your tech guys to answer these, and you might even be tempted to censor the results, but rest assured there is no way any board would score 100%, so not to worry. I can promise you, I personally will only buy from a manufacturer who does a reasonable job of disclosing some of this information, or disclosing enough technical information that I could deduce the likely answers for myself. I am eager to buy, and I am sure there are lots of other people out there like me.

---

ibm.pc/long.messages #140, from matt.trask (Matt Trask).
A comment to message 138.

That was quite a well-thought-out diatribe, Roedy. For my two cents worth on the subject:

My first task when I worked at Phoenix Technologies was maintenance of the Pfaster/286 support software. I got to do fun stuff like making the video go faster (without snow, of course) and writing diagnostics. I also wrote some boot code and an Above Board emulation.

My assessment of accelerator boards (the marketing people called that one an AT emulation, not an accelerator) is that it is probably *not* possible to get a general-purpose device such as you are asking for. If your typical end user has limited uses in mind such as speeding up 1-2-3 or long database sorts, most any speedup card is OK; look for a good price.

I used a lot of competitors' cards when I was on the project, and they all have major shortcomings that I believe prevent them from being useful as general-purpose tools. I found that the Pfaster in my XT clone at home was useful while developing software -- assembles, compiles, and links were much faster than an AT, and because I was testing and debugging on a "virtual machine," a reset was simple when it crashed -- I just exited to the 8088 and restarted the Pfaster. I can totally recommend the board for this kind of use.

However, I understand that the sales to your average end user (with general-purpose needs) were so dismal that the product was discontinued, and over 10,000 board blanks went in the dumpster. Can I interest you in a slightly used accelerator, cheap?

continued

How best to speed up a slow PC? While some people leap at the idea of an accelerator board, a number of others suggest ways that are cheaper, easier, or just different.

OPTIONS FOR SPEED

ibm.pc/hardware #2903, from rs_wood (Scott Wood).

I want to increase the power and speed of my XT. I don't have a lot of bucks, so I am looking for something fairly inexpensive yet reliable. What options does anyone suggest?

ibm.pc/hardware #2904, from condorwizard (Jim Morgan).
A comment to message 2903.

A fairly inexpensive speedup that I just implemented for my XT was a new turbo motherboard. The cost: around $100 +/-, depending on where you buy it. I used my existing boards and RAM. To populate it with RAM could add between $30 and $120, depending on how much and how fast. This gives me 4.77 MHz and 8 MHz. Don't listen to the baloney that 8 MHz speeds the system by 300%; it's more like 50%. You can boost that speed slightly by buying a V30-8 chip, which I believe sells for $30 or $40. There was a trade-off for me. Now my JRAM-2 board will not work at 8 MHz and will not extend my DOS memory at 4.77 MHz. Anybody want to buy a JRAM-2 board with 2 megabyte of 150-ns memory?

ibm.pc/hardware #2905, from billn (Bill Nicholls).
A comment to message 2904.

You want a V20-8 chip; the V30 is 8086-compatible, and the V20 is 8088-compatible. Also, be aware that MS Word seems to have problems running on a V20 chip.

ibm.pc/hardware #2910, from rmorse (Ron Morse).
A comment to message 2903.

Orchid Tiny Turbo or Turbo EGA. Not the fastest available, but reliable, and they have a very low "fussy factor." My turbo EGA seems to be compatible with just about everything. Don't put the Tiny Turbo in slot 8. Aloha from Paradise.

ibm.pc/hardware #2915, from bitwit (Ariffin Yahaya).
A comment to message 2910.

If you want REAL speed, go for a speedup card from the PC User's Group that has a 12-MHz 80286 on it; it *flies*. Actually, I might have fudged the name of the company. Does anybody know what I am talking about?

ibm.pc/hardware #2916, from flanga (Fred Langa, Executive Editor, BYTE).
A comment to message 2915.

Do you mean the Portable Computers Support Group (PCSG)? Their speedup card wouldn't work at all in my PC's Limited Turbo clone, and it took almost 3 months and a spate of registered mail before I could get my money back, per their guarantee.

ibm.pc/hardware #2921, from jfleming (Jon Fleming).
A comment to message 2916.

A friend of mine couldn't get either of two PCSG speedup boards to work at all in his true-blue PC. They were fairly nice about replacements and refunds, though.

ibm.pc/hardware #2976, from condorwizard.
A comment to message 2903.

I wrestled with the question myself and settled on buying an AT clone. Since then, my XT burned up, and I got a Turbo XT bare-bones chassis as a cheap way out. I'm very disappointed in the lack of effective speed as compared with the AT. For anyone who doesn't know -- a 6-MHz AT runs circles around an 8-MHz XT. A 10-MHz AT is just out of sight both for processing speed and hard disk access. I took a "fast" hard disk from my AT and put it in the Turbo XT -- what miserable performance. It isn't the disk, it's just the lousy way that 8-bit XTs work.

For the low money today for AT clones ($600 for a bare system), pull the boards out of the XT and put them in a base chassis. I don't believe you can beat that speed and price with any accelerator board.

ibm.pc/hardware #2980, from habrams (Howard Abrams).
A comment to message 2976.

There is a company out of California selling a "Bullet-286" that is an XT-size 80286 main board with eight XT slots. They will sell it for about $400 including 1 megabyte of memory (the top 384K is used by ROM as a disk cache). Since most accelerator boards sell for the same money, why not get the whole thing? (If I'm allowed to, I'll be happy to post the name of a rep.)

ibm.pc/hardware #3309, from rgrenader (Robert Grenader).

Regarding speeding up XTs and ATs: My experience is primarily confined to XTs and Compaq Deskpros, which use the 8086 CPU. Ninety-nine percent of the accelerator cards, etc. cannot support systems utilizing the 8086. I have seen ads for an add-on board that provides extended memory and a disk cache, as well as offering the benefits of an 80286 CPU. I think it's called Fast Cache 286, or something like that.

As an alternative, have you considered swapping the Intel 8088 for a NEC V series? I did replace the CPU in my Compaq with a V30, and have had NO compatibility problems. The Norton Sysinfo (inaccurate, but widely available) rating went from 1.8 to 3.6-9 (both at 8 MHz), and there was a noticeable increase in speed. How much? Realistically, in the 10% to 18% range, not 25%+ as has been claimed. Check the CPUS/v30v30 conference for more details. Besides, it is a really creative and fiscally sound alternative ($12-$16 per PC).

Bottom-line types will applaud you.

ibm.pc/hardware #3310, from sparks (Dave Sparks).

I have the Orchid TinyTurbo286 board. It tripled the speed of my 4.77-MHz PC clone. I paid $399 for it, but have seen it as low as $349 lately. Prior to that, I bought the 12-MHz Breakthru board from PCSG but was not able to get either of two different boards working. Further, 6 weeks after I returned the board (after obtaining the necessary return authorization) I still had not received a credit. Upon calling the company, they told me that the board was "still in receiving." Meanwhile, I'm paying interest charges on money that they have. GRRRRRRRRRRRRRRRRRRRR! (This has not been a review.)

ibm.pc/hardware #3311, from irae (Ira Emus).

I have used an Orchid Turbo 186 (2x PC speed), Fast 88 (1.6x PC speed), and at work we use an Orchid TinyTurbo286 and Turbo 286E (8 MHz). They have all worked reliably except the Turbo 186, with a very small amount of software. My favorite is the Turbo 286E because it's really an 8-MHz zero-wait-state AT in disguise. (It screams.)

pc/hardware #3315, from condorwizard.

The cheapest way to speed up a standard XT is buy a Turbo motherboard and put in a V-20 chip. Cost: less than $200, depending on the amount of RAM installed. All your XT boards should work without problems, but you might want to kick up your power supply. I know I did. As for ATs, the V-30 and faster RAM will help some. The biggest speed function that I noticed was putting in a decent drive. ■



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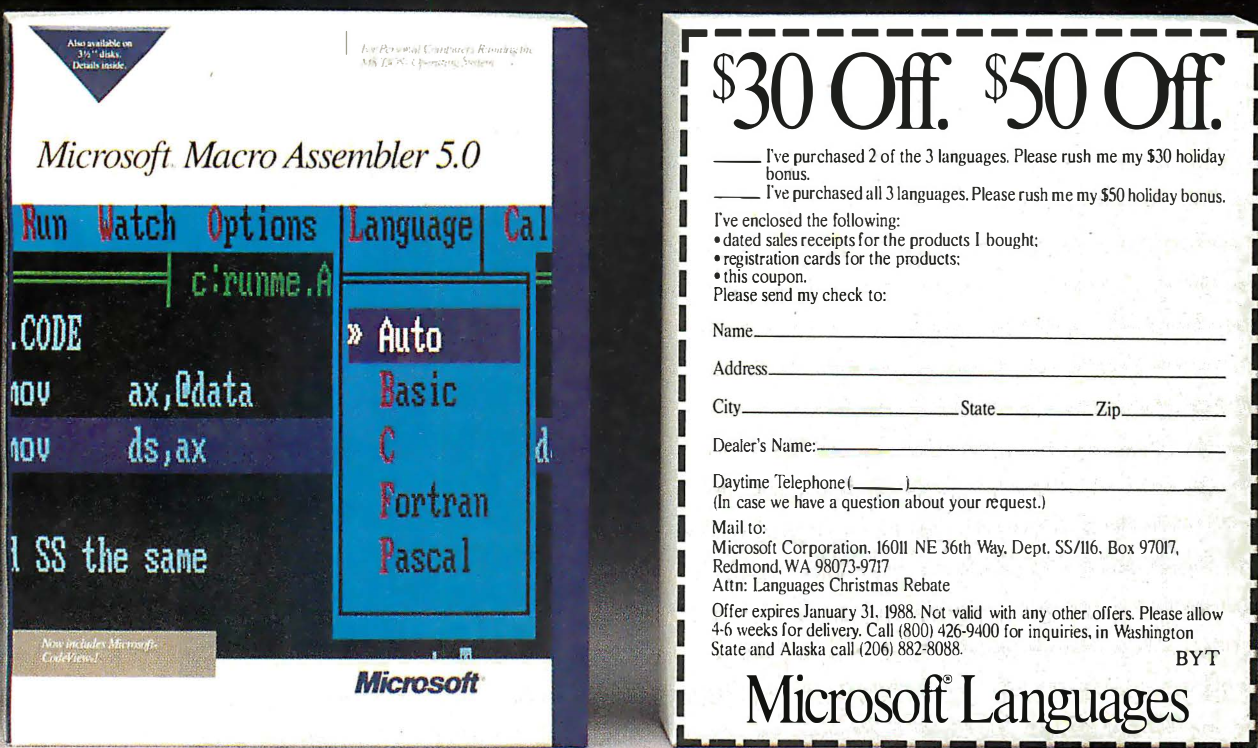
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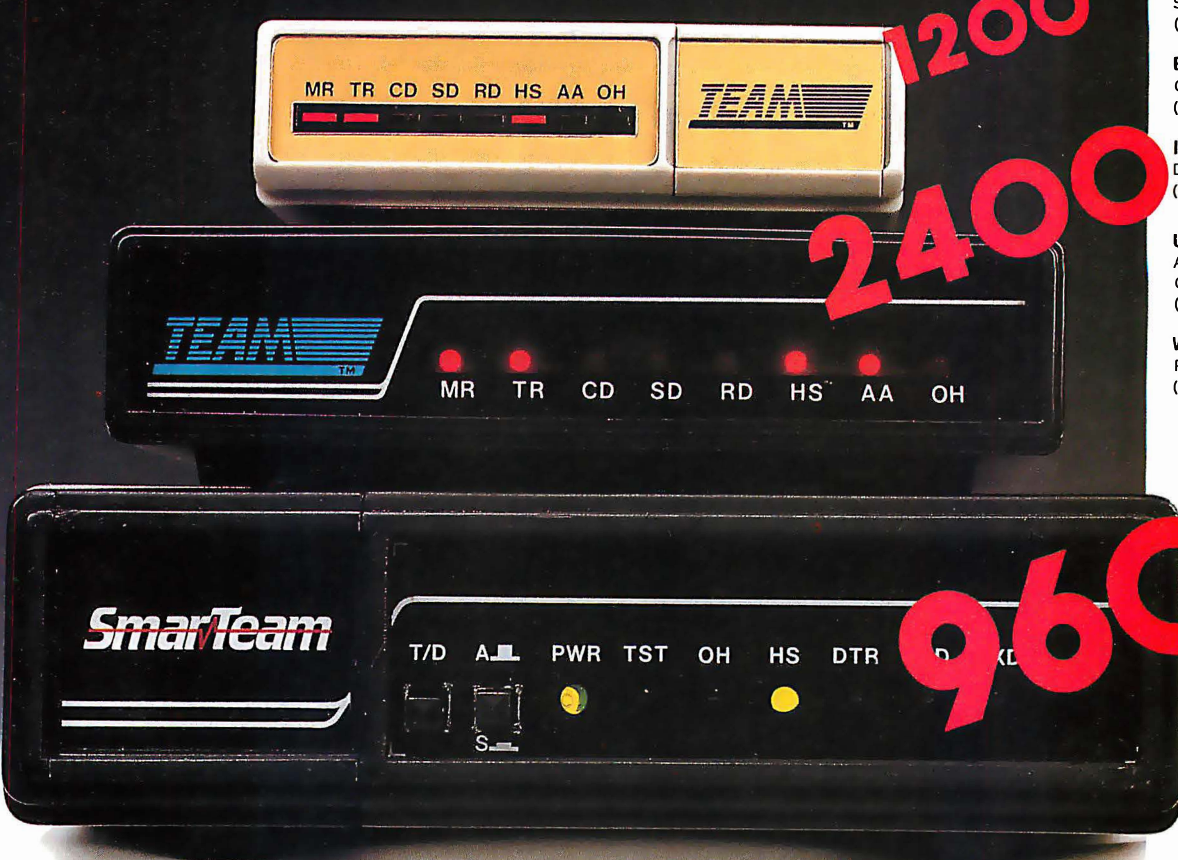
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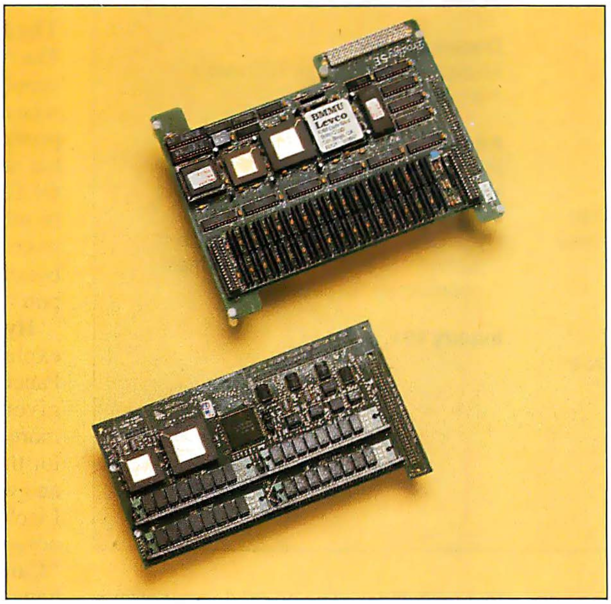
Laurence H. Loeb

Two 68020 accelerator boards that pack Mac II power into a Mac SE

One of the promising features of the Macintosh SE has been the 96-pin internal expansion connector that provides access to the 68000 CPU. This expansion port lets you use plug-in boards from third-party vendors to augment the capabilities of the basic Macintosh SE computer. Such boards are now starting to emerge. Two of the first to appear are Levco's Prodigy SE ($1499) and General Computer Corp.'s HyperCharger 020 ($999 and up).

These two accelerator boards aim to improve the throughput of the machine by either increasing the processor speed or providing improved functionality with a math coprocessor and extra memory.

Each of the boards reviewed replaces the Macintosh SE's original 8-megahertz 68000 processor with a 16-MHz 68020 and adds 1 megabyte of 32-bit memory. Both have sockets for an optional 68881 math coprocessor or floating-point unit (FPU). But these boards differ in the design and implementation of features.



The Prodigy SE (above) and the HyperCharger 020 (below).

The Prodigy SE

Levco was one of the first vendors to offer performance upgrades for the Macintosh while that computer was still a closed system, and the company has obtained a reputation for quality engineering and innovative design. The Prodigy SE is essentially a repackaging of the Prodigy Prime, an $1899 product offered for the Macintosh Plus.

The Prodigy SE offers the same basic features as the Prodigy Prime: a 68020 processor running at 16 MHz, sockets for a 68881 FPU and a 68851 paged-memory-management unit (PMMU), and 1 megabyte of 32-bit RAM, expandable to 4 megabytes. The Prodigy SE varies from the Prodigy Prime only in the way that it mounts on the SE motherboard.

When the Prodigy SE is installed, the native 68000 processor is hardware-bypassed during boot-up, and full control of the computer is given to the Prodigy SE's 68020 processor. Since the bypass is done in hardware, no additions to the System file are necessary.

A file called Prodigy adjusts important 68020 and board parameters as required for software compatibility. This control file (called a cdev, for "control-device resource") is placed inside the System folder and appears automatically in the Control Panel display when that desk accessory is brought up. Thus, if your Mac SE has a hard disk drive, you place this file in the drive's System folder. If your computer is floppy-disk-based, you will have to place a copy of this file on each of your system disks. Since it's only 4K bytes in size, keeping duplicates of the file on floppy disks is no problem.

The Prodigy control file enables or disables the 68020 instruction cache and determines whether the 68881 or Standard Apple Numerical Enviroment (SANE) is used for math operations. The file also contains a MacWrite 4.5-compatibility "Sniffer."

The cache control lets you turn off the 68020 instruction cache for those programs that don't work well (or at all) with the cache on. The SANE/68881 control determines whether the SANE calls use an emulation math library or the 68881 math coprocessor. The MacWrite 4.5 Sniffer patches the 68020 environment to enable MacWrite 4.5 to operate. This patch is necessary because MacWrite uses its own 68020-incompatible TRAP vectors; the problem is not the fault of the board vendors. [Editor's note: *The patch is not required with Apple's recently released MacWrite version 4.6, which is 68020-compatible.*]

The Prodigy SE board uses an interesting technique to boost performance: It causes Macintosh ROM code to be automatically copied into RAM at boot-up. With the copy of the ROM residing in the faster 32-bit memory, the board can get to the most-used routines of the Macin-

continued

Laurence H. Loeb is an electrical-engineer-turned-dental-surgeon and is co-moderator of the Macintosh conference on BIX. He can be reached at PBC Enterprises, P. O. Box 925, Wallingford, CT 06492, or on BIX as "lloeb."

Prodigy SE

Type
68020 accelerator board

Company
Levco
6160 Lusk Blvd., Suite C-100
San Diego, CA 92121
(619) 457-2011

Features
Processor: 16-MHz 68020
Memory: 1 megabyte of 32-bit RAM
Expansion port: 16-bit peripheral expansion bus for video monitors
Software: Prodigy utility control-device file; recoverable RAM disk program
Other: Socket for 68881 math coprocessor; socket for 68851 paged-memory-management unit

Hardware Required
Macintosh SE

Software Required
System 3.2/Finder 5.3, or System 4.1/Finder 5.5

Options
16-MHz 68881 math coprocessor: $299
2-megabyte 32-bit RAM module: $799
4-megabyte 32-bit RAM module: $1699
96-pin bus-transfer expansion connector: $149

Documentation
33-page *Prodigy SE Installation Guide*
55-page *Prodigy User Guide*

Price
$1499

Inquiry 890.

HyperCharger 020

Type
68020 accelerator board

Company
General Computer Corp.
215 First St.
Cambridge, MA 02142
(617) 492-5500

Features
Processor: 16-MHz 68020
Expansion port: 76-pin expansion port
Software: HyperCharger INIT utility; HyperCharger control-device file
Other: Socket for 68881 math coprocessor

Hardware Required
Macintosh SE

Software Required
System 4.1/Finder 5.5

Documentation
28-page HyperCharger 020 user's manual

Price
HyperCharger 020: $999
HyperCharger 020 with 1 megabyte of 32-bit RAM: $1299
HyperCharger 020 with 1 megabyte of 32-bit RAM and 8-MHz 68881 math coprocessor: $1699

Inquiry 891.

tosh without the added steps needed to look up information in ROM, and thus retrieve the routines more quickly.

For situations where you need the conventional Macintosh SE system, Levco provides a way to bypass the Prodigy SE board and use a 68000-emulation mode. You enter this mode by pressing a sequence of buttons on the programmer's switch mounted on the left side of the Mac SE; control then passes to the Mac SE's motherboard.

The HyperCharger 020

Like Levco, General Computer Corp. (GCC) also entered the Macintosh performance market by providing an internal hard disk for closed Macintosh systems. The HyperCharger 020 board provides a 16-MHz 68020 processor with a socket for an optional 68881 math processor. The board can be populated with 1 megabyte of 32-bit memory and is expandable to 4 megabytes. The board doesn't offer a socket for a 68851 PMMU. The HyperCharger 020 board uses the same type of single in-line memory modules (SIMMs) that the Macintosh II uses for memory expansion, so the memory is available from other sources.

The mechanism that General Computer uses to start the HyperCharger 020 differs from Levco's. A 1.5K-byte file called HyperCharger INIT is supplied with the board. INIT files contain initialization code that the Macintosh loads as it starts up. The HyperCharger INIT adjusts the default state of the board to standard Apple SANE processing, allows the use of MacWrite 4.5, and also copies a portion of the Macintosh ROM into the HyperCharger's 32-bit memory to improve performance.

Like Levco, General Computer supplies a cdev file, named HyperCharger, that appears in the Control Panel and lets you modify certain board parameters. You can select the type of math package to be used for computations (Off, GCC SANE, or Apple SANE), turn the 68020 cache on or off, and turn the MacWrite 4.5 compatibility option on or off.

With the math-processing control, the Off setting causes all computations to be done in software, the GCC SANE setting uses GCC's proprietary software with the 68881, and the Apple SANE setting uses Apple's SANE package, which uses the 68881 when possible and otherwise uses software for maximum accuracy. The 68020 cache control and MacWrite 4.5 compatibility controls are similiar in function to the Levco controls.

The cdev file is 18K bytes in length and should be included with any system disk (hard or floppy) used with the board. You can't disable the HyperCharger 020 to run the Mac SE normally.

The Boards Contrasted

The two companies differ in the ways they supply their boards to the end user. GCC relies heavily on its dealer network to provide not only installation of the boards but also end-user support. If you call GCC with a question, you will generally be referred back to your dealer for the answer. Thus, choosing a dealer for a GCC board is an important consideration in the purchasing decision.

HyperCharger's short user's manual explains how to operate the Control Panel, how to size the RAM cache for a given amount of memory, and little more. The installation manual supplied for this review was directed to the dealer and written at the level of the Apple Class I technician. In other words, it is not for novices. For example, it simply states, "Carefully separate the Macintosh SE housing parts," and "Discharge the anode." If you're used to poking around in the innards of a Macintosh, this document is adequate. If you have little idea of what is involved in working in a cramped computer housing with high-voltage equipment, then you'd better leave the installation to your dealer.

Levco, on the other hand, does not assume that you will have someone else install the board. For example, unlike the HyperCharger, the Prodigy SE comes with the Torx screwdriver needed to open the Mac SE's case. Although the installation manual contains plenty of legal boilerplate stating that you follow the described procedures at your own risk, the manual is presented so that any competent person can install the board. For example, it shows in detail the way to open up the Mac SE's housing, and it is lavishly illustrated with diagrams presenting the Macintosh as you see it during the

board installation procedures.

Instructions are broken down into simple tasks, much as Heathkit used to do. This is useful, since you will encounter a few quirks during installation. For example, the Prodigy SE is mounted at a slight angle to the motherboard surface, requiring appropriate placement of pairs of long and short spacers. (The HyperCharger mounts flush to the SE expansion connector and requires only two spacers.)

The HyperCharger uses SIMMs to allow the single megabyte of on-board 32-bit memory to be compactly stored at a 45-degree angle. As in the Macintosh SE, you can increase the amount of RAM on the HyperCharger by using higher-density SIMMs. The advantage of using easily available SIMMs is negated, however, by General Computer's policy of having a dealer install the board.

The Prodigy SE achieves a high component density by using surface-mounted devices. Levco's board currently lets you expand to 4 megabytes by using special memory modules. These modules aren't SIMMs, however, so they can't be used in another Macintosh computer, and you can obtain additional modules only from Levco. The Prodigy SE board will be upgradable to 8 megabytes when the higher-density modules become available. Due to the location of the Macintosh ROM within the 68020 address space, any memory expansion above 4 megabytes will require the use of the PMMU to handle address conversions.

The HyperCharger documentation suggests that, for best performance, the 1 megabyte of Mac SE memory be used as a cache. The reason is that the Mac SE's memory is 16-bit, and by assigning it as a RAM cache, you force applications to be located on the HyperCharger's faster 32-bit memory. In contrast, the Prodigy SE does not allow you access to the Mac SE's memory at all.

Performance and Compatibility

Both of the reviewed boards had a 68881 math coprocessor. However, the presence of this chip doesn't mean better performance unless the chip is used by the software.

To test performance, I ran a series of C language benchmarks. I first compiled the benchmarks with Lightspeed C 2.01, which generates 68000 code only and no 68881 instructions. Next, I compiled these benchmarks with Consulair's Mac C 5.04 68020 version, which generates 68881-specific instructions. To simulate normal board use, I ran the HyperCharger with a 1-megabyte RAM cache. Results of the benchmarks are summarized in table 1.

continued

Table 1: *The results of the C language benchmarks. For details on these benchmarks, see "A Closer Look" by Richard Grehan in the September BYTE. The HyperCharger 020 was run with a 1-megabyte RAM cache to ensure that the programs ran in the board's 32-bit memory. All times are in seconds, with the exception of the Dhrystone results, which are in Dhrystones per second. Dhrystone version 1.1 was used for 50,000 iterations and no register variables. "LSC" indicates that the program was compiled with Lightspeed C version 2.01, and "Mac C" indicates Consulair's Mac C 5.04 (68020-specific version). For the FPU results, each column indicates a control setting for the particular board.*

	Prodigy SE		HyperCharger 020	
Compiler	**LSC**	**Mac C**	**LSC**	**Mac C**
Dhrystone	3125	2380	3125	2176
Fibonacci	51.81	71.45	52.08	71.6
Float	17.98	2.61	27.28	4.06
Savage	52.08	5.21	52.69	8.86
Sieve	10.58	14.83	10.63	14.92
Sort	18.56	20.41	18.60	20.55

	Prodigy SE		HyperCharger 020		
	68881	**None**	**GCC SANE**	**Apple SANE**	**None**
Float	17.98	35.62	27.54	27.19	83.10
Savage	52.08	643.37	52.69	458.91	1810.87

Savage results, using Lightspeed C:

HyperCharger 020	
GCC SANE:	2.50000000000010e+004
Apple SANE:	2.50000000000004e+004
None:	2.50000000000004e+004
Prodigy SE	
68881:	2.50000000000008e+004
None:	2.50000000000004e+004

Table 2: *Conventional benchmarks. The Write and Read times show how long it takes to write and then read a 64K-byte sequential text file. (For the program listings, see BYTE's* Inside the IBM PCs, *Fall 1985, page 195.) The Sieve times show how long it takes to run the Sieve of Eratosthenes benchmark. The Calculations times show how long it takes to do 10,000 multiplication and 10,000 division operations. The 40K File Copy times show how long it takes to copy a 40K-byte file using the system utilities. The Spreadsheet Load times show how long it takes to load and recalculate a 25- by 25-cell spreadsheet in which each cell equals 1.001 times the cell to its left. All times are in seconds. All tests were performed using System version 4.1 and Finder version 5.5. Microsoft BASIC version 2.1 was used for the system benchmarks. Multiplan version 1.1 was used for the Spreadsheet tests. 800K-byte blank floppy disks were used for the file tests. The 40K Format/Disk Copy test was not performed because the computer had only one floppy disk drive.*

	Write	Read	Sieve	Calculations
HyperCharger	14.95	11.63	22.44	6.5
Prodigy SE	14.45	6.18	20.79	5.76
Mac SE	18	15	68	19

	40K File Copy	Spreadsheet Load	Spreadsheet Recalculate
HyperCharger	6.05	3.1	3.17
Prodigy SE	6.34	2	2.19
Mac SE	6.0	7.8	8.9

Interestingly, the Dhrystone results with Lightspeed C were identical for the two boards, at 3125 Dhrystones per second. In addition, both boards outranked a Macintosh II, which ran at 2631 Dhrystones per second.

Floating-point benchmarks, which depend heavily on the math coprocessor, show the difference in performance between the HyperCharger 020 and the Prodigy SE for these types of tasks. For example, the Float and Savage benchmarks using Mac C's 68881-specific code ran between 64 percent and 58 percent slower on the HyperCharger 020 board than on the Prodigy SE. This is partly because the HyperCharger's 6881 chip runs at 8 MHz, as compared to 16 MHz on the Prodigy SE board.

I found little difference in the times for the benchmarks that depend on integer arithmetic, such as the Sieve. Here the difference between the benchmarks varied by less than 1 percent.

I also ran the Float and Savage benchmarks with and without the 68881 FPU, by adjusting settings in the accelerator board's Control Panel. I compiled these benchmarks with Lightspeed C, because Mac C's in-line 68881 code bypasses the FPU's Control Panel settings. From the results, also shown in table 1, it's obvious that the math coprocessor improves performance significantly. For the Savage, it takes 12 to 34 times longer to get a result without the FPU.

You should also note the difference between the types of software libraries and how they use the math coprocessor. GCC SANE and Apple SANE both use the FPU when possible, although Apple SANE will use software emulation for maximum precision. The effects of this become evident when you compare the GCC SANE times to the Apple SANE times for the Savage benchmark. GCC SANE processes transcendentals faster, but at the expense of accuracy. (See table 2 for the conventional benchmarks.)

Both boards had the same compatibility with existing software. Most software ran with the 68020's cache on, which was somewhat surprising: I had heard that 68020 incompatibility was rampant in Macintosh software. Some older programs bombed with the cache on, but with a few exceptions, this was correctable by turning off the cache from the Control Panel. Dreams of the Phoenix's Phoenix 3D editor bombed during quitting, after showing a fivefold increase in drawing and calculation speed, and Easy-3D bombed with the cache turned off during program execution. This was disappointing; I had hoped that with the 68020's speed these programs would now be easily usable (i.e., fast). The MacWrite 4.5 patches worked on both boards.

Sound output from all programs was garbled when the boards were used. You can use the Prodigy SE's 68000-emulation mode to produce normal sounds, but the HyperCharger 020 board does not offer this solution. It can't be removed from the system, even if you delete the board's software-control programs.

I also evaluated the boards on expandability. Both bring out signals so you can make electrical connections for larger monitors, for example. The HyperCharger 020 brings out 64 pins and a 12-pin control bus into an expansion connector that the E-machines Big Picture monitor can plug into. The Prodigy SE board has a peripheral expansion bus with 16 additional data lines that can connect to MicroGraphic Images' 19½-inch MegaScreen or to SuperMac Technology's 19-inch monitor. You can obtain an optional bus-transfer expansion connector for the Prodigy SE that passes all the Macintosh SE's bus signals to connect an additional expansion board.

Should One of These Fill That Slot?

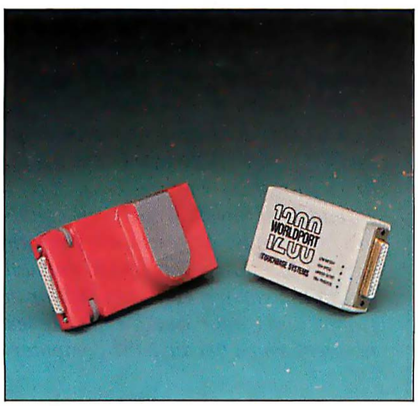
Both of these boards significantly increase the computing power available to Mac SE owners. Now you can have your cake and eat it too, because these accelerator boards bring the processing power of a Macintosh II to a transportable Macintosh SE and give you the option of connecting a large display. Since the boards are approximately the same price if you get the HyperCharger with 1 megabyte of memory, the comparison must be made on performance factors.

The Prodigy SE wins on both performance and peripheral expandability. In addition, for those who want to install the boards themselves, the Levco product is better supported, since the installation manual is written with the nontechnician in mind. However, for those who don't need the added features of the Prodigy SE, the Hypercharger 020 should not be ignored.

Before purchasing a board, evaluate your computing needs and make your choice based on those needs. If you just want to run Excel faster, then the HyperCharger 020 with a 68881 will do. But if you want an accelerator that has plenty of room for growth and that you can install yourself, the Prodigy SE is the choice. Both boards work well, but the Prodigy SE does it better. ■

Traveling Modems

Pete White



The Pocket Modem from Migent and the Worldport 1200 from Touchbase Systems.

I like portable modems for three reasons: They're small, they can take the place of existing modems in portable computers (e.g., Tandy Model 100) for faster data-transfer rates, and you need only one modem to work with both your desktop and portable computers. But these advantages are balanced by the disadvantages of lack of audio monitoring and limited modem status display. In these respects, a portable modem isn't as convenient as, for example, a full-size external modem.

Let's define a *portable* modem as being pocket-size and battery operated. When I was writing this review, only two modems fell within this definition of *portable:* the Pocket Modem from Migent, and the Worldport 1200 from Touchbase Systems.

The Pocket Modem is a 5- by 2½- by 1⅓-inch unit weighing 9 ounces with the battery installed. The modem can operate for up to 10 hours on a standard 9-volt DC alkaline battery (supplied). It has a female DB-25 connector on one end, and two RJ-11 connectors and an external power supply connector at the other end. The case at the DB-25 end is $1\frac{1}{16}$ by $2\frac{3}{8}$ inches and has two thumbwheel screws to attach the modem to the computer. Inside the case is a single printed circuit board (4½ by $2\frac{5}{16}$ inches) containing all the circuitry.

The modem operates at 300 and 1200 bits per second and is Bell 212/103- and

Hayes AT command set–compatible. The package includes the BitCom communications program. The modem has no configuration switches to set; you set all options using AT commands. The parameters are stored in the unit's internal nonvolatile memory. The list price for the Migent Pocket Modem is $259.

The Worldport 1200 is a 4- by 2⅖- by 1-inch unit weighing 6½ ounces with the battery installed. As with the Pocket Modem, it operates for up to 10 hours on a standard 9-V DC alkaline battery (supplied). It has a DB-25 connector at one end (available with a male or female DB-25). A single RJ-11 connector is on one side of the case, and the external power supply connector and acoustic coupler interface connector are on the other. Four LEDs on the top of the case go on, off, or flash to show the modem's status.

The case at the DB-25 end is 2⅖ by 1 inches; it does not have any screws to attach to the computer. Inside the case are two small circuit boards, each 2⅛ by 2⅛ inches long, stacked one on top of the other. The rear 1½ inches of the case contains the battery.

The Worldport 1200 operates at 300/1200 bps and is Bell 212A/103–, CCITT V.21/V.22–, and Hayes AT command set–compatible. It has an internal bank of four switches for setting the Bell or CCITT standard, auto-answer enable, power-on sense, and data-terminal-ready (DTR) ignore. The list price for the Touchbase Systems Worldport 1200 is $199.

Both units operate with an external power supply as well as with the 9-V DC battery. Neither modem has any internal audio signaling.

[Editor's note: *Touchbase Systems has announced its Worldport 2400, at a list price of $359. This 2400-bps portable modem, which has audio circuitry, will be bundled with Carbon Copy Plus communications software. Owners of Worldport 1200 modems can have them upgraded at a cost of $199, which includes Carbon Copy Plus.*]

Pocket Modem

Type
Battery-operated portable modem

Company
Migent Inc.
865 Tahoe Blvd.
P.O. Box 6062
Incline Village, NV 89450
(702) 832-3700

Size
5 by 2½ by 1⅓ inches; 9 ounces (with battery)

Features
9-V battery included; AC power supply; 7-foot modular telephone cord; DB-25 cable (M/F); DB-9 cable (M/F); 5-year warranty

Software
BitCom communications program

Options
Carrying case: $7.50

Documentation
36-page *Pocket Modem User's Guide*; 82-page *Software Guide*

Price
$259

Inquiry 892.

Worldport 1200

Type
Battery-operated portable modem

Company
Touchbase Systems Inc.
160 Laurel Ave.
Northport, NY 11768
(516) 261-0423

Size
4 by 2⅖ by 1 inches; 6½ ounces (with battery)

Features
9-V battery included; 7-foot modular telephone cord; 2-year warranty on the modem, 1 year for connectors

Options
AC power supply: $6.95
DB-25 cable (M/F): $20
DB-9: $20

Documentation
90-page *Installation and Operation Manual*

Price
$199

Inquiry 893.

Hardware and Software Tests

Testing portable modems is best done using portable computers. I used a Zenith Z-181, a Zenith Z-171, and a Toshiba T1100 Plus. I also used a Leading Edge MH-11 and a Multitech 900 desktop computer. I utilized the following external modems for comparison at 300 and 1200 bps: the USRobotics Courier 2400, the Hayes Smartmodem 2400, and the Novation Professional 2400.

All the modems were put through the same tests simultaneously to see if there were any obvious differences in performance between the full-size external modems and their portable cousins. Other than the fact that both portable modems were installed more easily, there were no differences in performance.

I configured several communications programs for the above equipment. The software packages I used were: Mite (version 3.02), ProComm (version 2.4.2), Pibterm (version 3.2.5), Telix (version 2.12), and BitCom (version 2.2). I also used TBBS (version 2.0M), a commercial messaging system and bulletin board system (BBS) program, and the Smart (version 3.1) communications module to test compatibility. I did the actual testing by calling the following systems: BIX, the BYTE Information Exchange (via local Tymnet); TBBS Support BBS, Colorado; TC-AMIS, Minnesota; and the Cul-De-Sac BBS, Holliston, MA (my own TBBS system).

I began by simply unpacking the modems, installing the batteries, and ataching each modem to the Zenith Z-181. The Worldport uses a snap-on battery connector. The Pocket's battery compartment has two contacts and a sticker that shows how to insert the battery. (The sticker was upside down.)

Migent ships the Pocket Modem with just about everything you'd need to attach it to any computer, including a DB-25 male/female cable and a DB-9 female to DB-25 male cable. The connector on the Pocket Modem is a female DB-25. You can order the Worldport 1200 with either a DB-25 male or a DB-25 female connector. I used the unit with the DB-25 female connector for all tests.

The Worldport 1200 plugged into the back of the Z-181 as if it were designed for that machine. The Pocket Modem would not fit because of a lack of space around the computer's connector. On the Z-171, on the other hand, the Pocket Modem plugged in with no problem, and the Worldport 1200 wouldn't fit because there wasn't enough clearance for the modem case. On the Toshiba T1100 Plus, you need an adapter cable to use either modem because the serial port has a DB-9 connector.

I disabled all initialization commands from the communications software to force each modem to start with its internal default configuration. I tested each modem with each software package to determine any differences in normal operation. Both modems performed almost flawlessly in all tests made during calls I initiated. The only exception was with the communications module included in the

continued

Both modems performed extremely well with a variety of hardware and software under various conditions.

Smart Integrated System from Innovative Software. The Hayes modem configuration required a true Hayes modem. It was difficult to get most of the Hayes-compatible modems to work. While both portable modems initialized using the Smart Hayes 1200B configuration, the Pocket Modem indicated that it was already on-line when I attempted to dial.

Next, I used each modem to replace the external modem being used on a TBBS. Since TBBS sets up a modem for auto-answer, this was another test of Hayes-command compatibility. I used each modem on the TBBS, both on-line and off-line (a multiline TBBS places an off-hook indication on a modem when it goes off-line for maintenance). Surprisingly, the Worldport 1200 operated as well as the full-size external modem it replaced, with no problems at either 300 or 1200 bps.

Initially, the Pocket Modem would not answer any incoming calls at either data-transfer rate. I changed the internal switch settings in the Pocket Modem and enabled the DTR (its default setting is "DTR sensing off"), and then repeated the test. This time it functioned correctly.

I used each modem to call the four telecommunications systems. Using the various software packages, I transferred text and binary files between the portable computers and these systems. I also timed files transferred to and from the Cul-De-Sac BBS at 300 and 1200 bps under controlled conditions. The difference between the modems in actual operation was negligible, even for tests run during a time when high humidity assured considerable line noise (sufficient to make 2400-bps communications extremely erratic).

The Two Compared

Both modems performed extremely well with a variety of hardware and software under various conditions. Nevertheless, there are differences between them.

The Pocket Modem has a nonvolatile memory for storing a command line or telephone number (up to 28 characters). It has configuration registers similar to the Hayes modem S registers, and the BitCom software provided has a Pocket Modem Setup program to help you set up

the communication parameters.

The technical reference in the *Pocket Modem User's Guide* lists the following: basic Hayes commands supported: latest Hayes 1200 commands supported, Hayes 2400 commands supported, and unique Migent modem commands (to set detection of dial tone, busy, remote ring, tone, and battery alarm). It also includes lists of the Hayes Smartmodem S registers and Migent modem S registers, to set data carrier detect (DCD) and DTR. The manual is reasonably complete in listing all the available configuration commands, but it lacks explanations of how the commands work and examples of how they are used.

The Worldport 1200 has four internal hardware switches and accepts almost all the Hayes AT commands; thus, it performs quite well with any software designed to use the Hayes-compatible commands.

The Worldport also uses configuration registers similar to the Hayes modem S registers. While the modem does not come with any communications software, the *Installation and Operation Manual* offers concise instructions on how to set the communications parameters, and it explains the function of each S register.

One significant difference in the circuitry of the Worldport 1200 is that it monitors the DTR signal and turns the modem off within 30 seconds if DTR goes low. This greatly extends the life of the battery. The Pocket Modem has no sensing circuitry, and the modem is on as long as the computer is on. This means you have to remember to detach the unit if you use your computer for something besides communications. The weight of the Pocket Modem makes it almost mandatory to use the thumbwheel screws to ensure the modem stays connected, so there's more to detaching the unit than just unplugging it.

Both units had no problems when using the external AC adapters. I recommend using the adapters whenever possible because this disconnects the battery automatically.

If you plan on traveling abroad, the Worldport 1200 has support for the CCITT V.21/V.22 standard protocols, used in most other countries. There is no CCITT support in the Pocket Modem.

The only status indication offered by the Pocket Modem is an alarm that passes a command to the audio circuit of your computer when the battery is low. The Worldport 1200 has four LEDs that report call-progress information, speed, and low-battery and carrier detect. I've learned to rely on both audio and visual indications of how a modem is operating, and having a visual indication is better than having none.

The Pocket Modem has two internal RJ-11 telephone connectors to let you attach a telephone to the modem. If you want this capability with the Worldport 1200, you have to purchase an RJ-11 Y adapter. The Worldport 1200 comes with an acoustic-cup adapter cable, for use with the Radio Shack acoustic cups. This makes the Worldport ideal for upgrading the Tandy Models 100/102 to 1200-bps communications.

Both manufacturers provide telephone support. In addition, Touchbase Systems has support available on several other services (e.g., Genie and MCI Mail) and has a toll-free support line, (800) 541-0345 (outside New York state only).

The Pocket Modem comes with a 36-page *Pocket Modem User's Guide* and an 82-page *Software Guide* for the BitCom communications program. The Worldport 1200 has a 90-page manual that contains a fairly comprehensive introduction to data communications.

Final Verdict

Since both modems perform the same, choosing one should be based on the best price and the most useful features and options. My choice would be the Worldport 1200 because it has a few more useful features than the Pocket Modem. If you need to telecommunicate from foreign countries, the CCITT support is already there.

If you have to use telephones that don't have plug-in RJ-11 connectors, the convenience of the Radio Shack acoustic cups helps considerably. It is also easier to install and remove the Worldport 1200, since there are no mounting screws to fuss with.

Despite the lack of audio monitoring on the Worldport 1200 and the lack of audio or status lights on the Migent Pocket Modem, in all other respects both modems performed well. Even if you're not interested in portable operation, either of these modems would be a good choice. ■

Pete White (P.O. Box 127, Holliston, MA 01746) is the owner of GW Associates, a consulting firm specializing in messaging systems and communications. He can be contacted as "petewhite" on BIX or via his BBS, The Cul-De-Sac, at (617) 429-1784.

VIEWS FROM BIX: PORTABLE MODEMS

laptops/long.messages #3, from Mark Szpakowski.

I'm interested in a "pocket" modem to carry around and plug into Macintosh computers. (I think that a computer without a modem is like a fish without a fin). Could you check on compatibility of the two reviewed modems with Macs? Cabling, of course, is the first thing to look at.

laptops/long.messages #4, from Ken Smith.

The Worldport modem works just fine with the Macintosh. I have not tested the Migent, but I don't see why it would not work. There are two cables available from Apple that you will want to look at. One is the Macintosh Plus adapter cable; it has the DIN-8 connector on one end and a DB-9 on the other end (part no. M0189). The other is the Macintosh 512K Imagewriter cable, which has a DB-9 to a DB-25 connector (part no. M0150). This connects a Mac 512K or the Mac Plus adapter cable to the modem. I could not find an Apple cable that directly connects the Mac Plus to the modem, but I am sure that one could be made. The Apple cables are available from most Apple dealers and cost around $20.

BIX Mail, from Larry Loeb.

I have used the Migent modem with a Macintosh. The modem must be attached with a cable converting the DB-25 to an Apple DIN-8. I agree with the review author that the lack of a hardware on/off switch is something of an annoyance if you are using batteries to power the unit.

I also liked the design of the modem case. The sticker in the battery compartment in my modem was correctly oriented. Thus, I suspect that the review author had an older unit.

Another area that should be more clearly understood is that, although the manufacturer provides a communications program that sets the parameters of the modem, it is the modem itself, not the program, that does the actual setting of these parameters. The program is an easy and simple way to send the correct commands for a desired result to the modem, but if necessary, it may be overridden while on-line with the appropriate command sequences. I value this flexibility in a small unit.

I have also found that the unit performs better on a noisy line at 1200 bps than my Anchor Express full-size modem does. The Migent suffers far less "line hits," in my experience.

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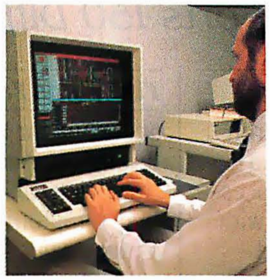
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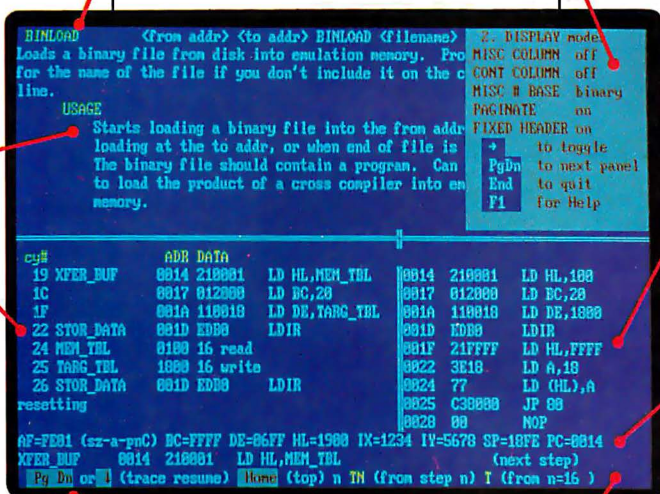
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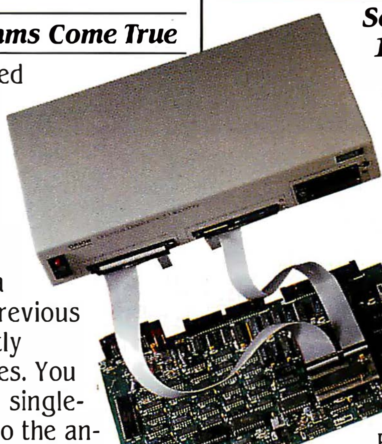
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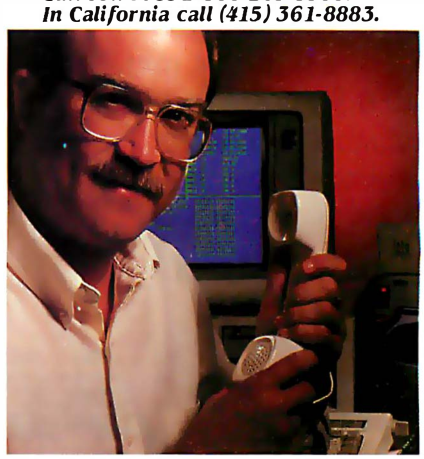
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Three FORTRAN 77 Compilers

David W. Burleigh

Interactive debugging and language extensions are no longer limited to mainframes

Three FORTRAN 77 compilers are now competing for the attention of engineering and scientific users of 8086-/80286-based personal computers: F77L-Lahey FORTRAN 77 2.2 ($477), Microsoft FORTRAN 4.0 ($450), and Austec's RM/FORTRAN 2.11 by Ryan-McFarland ($595). Each of these compilers supports the full ANSI X3.9-1978 FORTRAN standard (FORTRAN 77) plus extensions, and includes an interactive source-level debugger. Microsoft's package includes the Microsoft linker and library manager. The Austec package includes the Phoenix Plink86 linker and Plib86 object-code library manager. Lahey charges $195 extra for its P77L execution profiler and $75 for Plink86 ($50 if purchased with F77L FORTRAN), which is derived from Phoenix Computer Products Corp.'s Plink86.

Lahey FORTRAN F77L 2.2

Lahey FORTRAN F77L 2.2 is packaged in a single three-ring binder and slipcover; the compiler and debugger are supplied on a single disk. Lahey provides batch files to install the software on floppy disk or hard disk systems, but these files consist of little more than two COPY commands that copy the half-dozen or so necessary files.

The manual is a no-frills reference volume. Complete and precise, it is intended for the experienced FORTRAN programmer. Installation and usage notes are included in an appendix rather than in the introductory chapters. Other appendixes cover implementation specifications, the ASCII character set, F77L error messages, assembly language interface, C language interface, third-party software interface, programming hints, and the Source On-Line Debugger (SOLD). Regrettably, extensions to the FORTRAN 77 standard are not noted anywhere in the manual.

Compilation speed is Lahey FORTRAN's most remarkable feature; it is unbelievably fast. I used Lahey FORTRAN on an 8-megahertz IBM PC AT to compile a 50,000-line numerical-analysis system in less than 1 hour—less time, in fact, than it took to compile the same code as a single user on a DEC VAX-11/780. The quick compilation time costs you slower execution speed in most cases.

Lahey's diagnostics were the most complete and understandable of the three compilers. For example, this is the only compiler that issues warning messages for variables declared but never referenced, variables referenced but never initialized, and variables initialized but never referenced.

Lahey FORTRAN contains some other unique features, such as the ability to generate recursive functions, set registers, and issue DOS and BIOS interrupts. (For comparisons of compiler features, see tables 1 and 2.) This package also supports the NAMELIST statement, a random-number generator, access to command-line arguments, floating-point exception detection, and trailing comment fields via the ! delimiter.

In addition, Lahey FORTRAN has a unique debugging mechanism. You don't have to recompile to run the debugger; SOLD debugs the production program. The compiler stores symbol tables, line numbers, and other debugging hooks in .sld files separate from the object code. As long as these files and the original source files are accessible, you have full debugging support.

While Lahey's debugger doesn't have the multiple-window environment of Microsoft's CodeView full-screen debugger, it lacks very little functionally. It is very easy to set break or trace points at a range of source statements and to selectively or globally remove them. The ability to trace execution, displaying source lines as they are executed, is very valuable when you haven't a clue to where a bug is.

What is notably lacking in SOLD is a single-step command. While you can effectively single-step by turning on breakpoints for all statements (which can be done with a single command), it would be more intuitive to have a STEP command that doesn't set permanent breakpoints as it single-steps.

SOLD's N is remiss in that it literally sets a temporary breakpoint at the next source statement but fails to single-step when a branch skips over that source statement. Also lacking is the ability to set break/trace points by statement label without knowing the source line number.

Lahey's technical support is hard to beat. In addition to excellent call-in support, a Lahey bulletin board system is available for asking questions, sending in listings, and downloading patches. The compiler always processes a file named F77L.FIX, which can contain patches to the compiler in ASCII-coded form. The Lahey support personnel will dictate a patch to you on the phone or instruct you on how to download an updated patch file from their BBS, so you don't have to wait for the next release of the compiler.

The only significant missing ingredients in this compiler are bit setting, clearing, and testing functions; debug comment codes for conditional compilation; better code optimization; and an 8087-/80287-emulation library.

In all, the Lahey FORTRAN package is an excellent product tuned to the needs of professional FORTRAN developers. It has most of the language extensions that you need to port mainframe code from

continued

David W. Burleigh is a contract programmer for Burleigh Software Engineering (36 Moultrie Street, Boston, MA 02124) and holds a B.S. in engineering from the University of Michigan. He can be contacted on BIX as "dwb."

	F77L-Lahey FORTRAN 77 2.2	Microsoft FORTRAN 4.0	RM/FORTRAN 2.11
Type	FORTRAN 77 language compiler	FORTRAN 77 language compiler	FORTRAN 77 language compiler
Company	Lahey Computer Systems Inc. P.O. Box 6091 Incline Village, NV 89450 (702) 831-2500	Microsoft Corp. 16011 Northeast 36th Way P.O. Box 97017 Redmond, WA 98073-9717 (206) 882-8080	Austec Inc. (incorporating Ryan-McFarland Corp.) 609 Deep Valley Dr. Rolling Hills Estates, CA 90274 (213) 541-4828
Format	One 360K-byte 5¼-inch floppy disk	Seven 360K-byte 5¼-inch floppy disks or 3½-inch floppy disks	Three 360K-byte 5¼-inch floppy disks or 3½-inch floppy disks
Computer	IBM PC, AT, or compatible with at least 256K bytes of memory, two double-sided disk drives, and an 8087, 80287, or 80387 coprocessor	IBM PC, AT, or compatible with at least 320K bytes of memory (512K bytes recommended), two double-sided disk drives, and an 8087 or 80287 coprocessor (recommended)	IBM PC, AT, or compatible with at least 256K bytes of memory, two double-sided disk drives, and an 8087 or 80287 coprocessor (optional)
Software Required	MS-DOS/PC-DOS 2.0 or higher	MS-DOS/PC-DOS 2.0 or higher	MS-DOS/PC-DOS 2.1 or higher
Language	C and assembly language	C and assembly language	Programmed Operation Procedures Language (POPS)
Documentation	400+-page reference manual	500+-page user's guide and reference manual	500+-page user's guide and language reference
Price	$477	$450	$595
	Inquiry 896.	**Inquiry 897.**	**Inquiry 898.**

Table 1: *Extensions to the FORTRAN 77 standard.*

	F77L-Lahey FORTRAN 2.2	Microsoft FORTRAN 4.0	RM/FORTRAN 2.11
Access=append on open	Yes	No	Yes
*length data typing, $ alpha character	Yes	Yes	Yes
Data initialization in type declarations	Yes	Yes	No
Arrays with >7 dimensions	No	Yes	No
Binary (byte-stream) files	Yes	Yes	No
Comparison of `CHAR` to numeric	No	Yes	No
Debug comment-field switches	No	Yes	Yes
DOS 3.x file-locking/sharing	No	Yes	No
Escape to DOS	`SYSTEM` call	`PAUSE`	`PAUSE`
Flags undeclared variables	Option	Option	No
Free-form source code	Yes	Yes	No
Hexadecimal, Hollerith, format	Yes	Yes	Yes
`INTEGER*2`, `LOGICAL*1`, `COMPLEX*16`	Yes	Yes	Yes
`INTEGER*1`, `LOGICAL*2`	No	Yes	No
Automatic `INTEGER*2`	/t Option	`$STORAGE` Option	/i Option
`NAMELIST`	Yes	No	Yes
Non-base-10 constants	Hexadecimal	Any radix	Hexadecimal
Non-`CHARACTER` array, internal files	No	Yes	No
Pass arguments by value	Yes	Yes	No
Recursive calls	Yes	No	No
Set/Query I/O buffer size	No	Yes	No
Suppress `CR/LF` on output	& Format code	\Format code	\Format code
Trailing comment field	Yes	No	No

IBM and DEC VAX environments. It has a rich set of extra functions and subroutines for the DOS environment, and it compiles with blinding speed, gives excellent diagnostics, and has a powerful debugging system.

[Editor's note: *Lahey has announced a small-memory-model version of its F77L/SOLD combination. It's called Personal FORTRAN 77, and it sells for $95.*]

Microsoft FORTRAN 4.0

The Microsoft FORTRAN package includes three standard-size three-ring binders in slipcovers and seven floppy disks. Microsoft provides a fairly foolproof interactive installation program. The documentation is nicely typeset and well written, organized, and indexed, and it is replete with examples. A user's guide covers the installation procedure, how to compile and link, compiler options, and C and assembly language interfaces. Differences between Microsoft FORTRAN 3.3 and 4.0 are covered in an appendix, as are file and record formats, error messages, and compiler limitations.

The Language Reference is thorough and well organized. Intrinsic functions, extra procedures, and the ASCII character set are covered in the appendixes. Microsoft FORTRAN has almost all the language extensions that Lahey FORTRAN has, except recursion, `NAMELIST`,

continued



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APPEND file access, and trailing comments. In addition, Microsoft FORTRAN has numerous extensions to support linking with Microsoft C, Pascal, and assembly language routines, and a complete set of bit-manipulation functions. Its I/O system supports DOS 3.x file sharing and locking mechanisms.

Compilation is slow, taking two to four times longer than Lahey FORTRAN, but the compiler-generated code is compact and execution is 10 to 300 percent faster than the Lahey compiler's code (see table 3).

Unfortunately, Microsoft's compiler had problems with three of the 12 benchmarks I used for testing. The Sieve compiled and executed, but it complained of a pointer error upon exit. The text-formatting program compiled, but it did not execute correctly until I suppressed code optimization. The LINPACK program would not compile because of two complicated expressions; I had to break up the expressions before Microsoft FORTRAN could compile them. When I tried to interrupt the compiler with Control-C, my system crashed. (Neither the Lahey nor the Austec compilers had any difficulties with the 12 benchmark programs or with Control-C interrupts.)

The Microsoft compiler did not display the name of each program unit during compilation. This caused problems in finding the complicated expressions in LINPACK that were causing the compiler to choke. On the positive side, the compiler will optionally flag exceptions to the FORTRAN 77 standard.

As for technical support, the manual contains only mail-in problem-report forms. My attempts to get technical support by phone from Microsoft were unsuccessful. [Editor's note: *Microsoft now has telephone support for its products. To contact a Microsoft product specialist, call (206) 882-8089 and follow the telephone routing instructions for your particular product.*]

CodeView

Microsoft's CodeView debugger is in a class by itself. It displays source code in one window, registers in another, and dialogue with the user in a third window. Execution output appears on an alternate screen, during which time the debug windows disappear. You can interact with the debugger via the text cursor, a mouse, the function keys, and the dialogue window. You can move the cursor to a source line, press a function key to set a breakpoint, and execute up to that point. You can debug at the assembly language level if you like, stepping instruction by instruction. For debugging FORTRAN source code, CodeView is nearly functionally equivalent to Lahey's debugger, SOLD, but has a more flexible, dynamic user interface.

I appreciate the value of CodeView for debugging assembly language code. However, it was of no help in finding the problem with the text-formatting benchmark, since the problem disappeared when the debug option was enabled. CodeView's myriad features and powerful debugger make Microsoft FORTRAN 4.0 a promising product, but because of the benchmark-execution problems and its inability to compile complex expressions without intervention, it lacks robustness—at least in its current release.

[Editor's note: *Microsoft has announced the release of version 4.01 of its Optimizing FORTRAN Compiler. The company claims that this version corrects some problems in version 4.0 and provides faster* LOG *and* EXP *functions, which are heavily used in scientific and engineering applications. Microsoft will supply registered owners of version 4.0 with a five-disk upgrade kit free of charge. For versions lower than 4.0, there will be an upgrade charge of $150.*]

Table 2: *Compiler options.*

	F77L-Lahey FORTRAN 2.2	Microsoft FORTRAN 4.0	RM/FORTRAN 2.11
Allocate locals on stack	Yes	No	No
Assume >64K-byte adjustable arrays	Yes	Yes	Yes
Assume free-format source	Yes	Yes	No
Assume INTEGER*2 and LOGICAL*1	Yes	Yes	Yes
Conditional compilation	No	Yes	Yes
Control code optimization	No	Yes	Yes
Control listing line/page size	Yes	Yes	Yes
Display options on console	Yes	No	No
Enable 8087/80287 emulation	No	Yes	Yes
Enable arglist checking	Yes	No	No
Enable one-trip DO loops	No	Yes	Yes
Enable subscript checking	Yes	No	No
Flag extensions to 77 standard	No	Yes	No
Flag undeclared variables	Yes	Yes	No
Generate 80286-specific code	No	Yes	Yes
Generate cross-references	Yes	Yes[1]	Yes
Include allocation map	Yes	Yes	Yes
Include debugger information	Yes[2]	Yes	Yes
Include object code in listing	No	Yes	Yes
List INCLUDE files in listing	Yes	No	No
Perform link step	No	Yes	No
Perform syntax check only	No	Yes	No
Protect constant arguments	Yes	No	No
Restrict length of symbols	No	Yes	No
Specify listing (sub)titles	No	Yes	No
Specify object file name	No	Yes	No
Specify stack size	No[3]	Yes	No
Suppress warning messages	Yes	Yes	Yes
Suppress/enable listing file	Yes	Yes	Yes

Notes:
[1] Can produce cross-reference in link step only.
[2] Saves debug information in a separate file, rather than including it in the object code.
[3] Can ensure a minimum stack size on specific function calls.

RM/FORTRAN 2.11

RM/FORTRAN comes on three disks in a fabric-covered three-ring binder. An installation script at the beginning of the manual leads you through the two COPY commands necessary to install the compiler. The single binder contains a user's guide, which describes how to compile, link, run, and debug programs, and a language reference that describes RM/FORTRAN's superset of FORTRAN 77. A helpful quick-reference card is also included. Appendixes cover intrinsic functions, Hollerith and hexadecimal datatype usage, and extensions to the FORTRAN 77 standard.

There is little that is remarkable about this compiler, except perhaps its poor I/O performance. Compilation speed is slower than F77L's in all cases, and slower than Microsoft FORTRAN's in all but one benchmark. As the benchmark results in table 3 show, execution speed is faster than F77L's (except for I/O), but

continued

much slower than Microsoft FORTRAN's.

The compiler has most of the useful extensions to FORTRAN 77, but it lacks the ability to initialize variables in type statements, a common extension in mainframe compilers. The limitation of CHARACTER variables to 255 characters is too restrictive, given that the descriptor used to pass CHARACTER variables uses a 2-byte integer to specify length. (Other compilers allow 32K bytes or 64K bytes for character variables.)

Also missing is a mechanism to pass arguments by value or to manipulate addresses; this makes it impossible to link to C subroutines without an intermediate assembly language interface. Other serious missing attributes are a mechanism for fetching command-line arguments, a random-number generator, the NAMELIST statement, a free-format source-code option, and the ability to nest include files.

The diagnostics are adequate for the most part, although this compiler also declines to keep track of consistency in declaring, initializing, and referencing variables. Several messages have explanations in the manual that suggest calling your support representative or informing your supplier, although I searched the documentation in vain for any stated policy on technical support.

RM/FORTRAN's symbolic debugger

Table 3: *FORTRAN compiler benchmark test data.*

	Time (in seconds)			Size (in bytes)	
	Compile	Link	Execute	.obj	.exe
Floating-Point arithmetic (Calculations) (10,000 iterations)					
Lahey	2	11	2.36	765	24416
Microsoft	5	16	1.42	916	21936
RM/FORTRAN	4	11	2.47	924	29696
Eratosthenes Sieve (15,000 iterations)					
Lahey	2	12	2.09	888	24528
Microsoft	6	14	0.54	919	22016
RM/FORTRAN	6	11	0.77	1066	59824
Write 1024 128-byte records of character data					
Lahey	2	15	2.20	1155	29248
Microsoft	4	17	1.43	970	24992
RM/FORTRAN	5	11	4.12	1169	31440
Read 1024 128-byte records of character data					
Lahey	1	17	2.53	898	36480
Microsoft	4	18	4.89	850	26560
RM/FORTRAN	5	11	36.25	1066	31648
Write 1024 126-byte records of formatted numeric data					
Lahey	2	14	20.76	955	28992
Microsoft	4	17	13.45	901	24944
RM/FORTRAN	5	11	22.14	1086	31312
Read 1024 128-byte records of formatted numeric data					
Lahey	2	17	23.17	894	36464
Microsoft	4	18	21.81	868	28096
RM/FORTRAN	5	11	57.40	1060	31664
Write 1024 36-byte records of unformatted numeric data					
Lahey	1	15	0.88	979	30192
Microsoft	4	16	0.72	847	24496
RM/FORTRAN	4	12	1.54	1107	32080

is unsensational. It does not display source code, much less let you search source code for a string; you must have a listing on hand to debug your program. It will break on condition or a change of value, but it will not simply trace changes in value without breaking. It does, however, let you set breakpoints based on FORTRAN statement labels, a nice feature that other debuggers lack.

One advantage of RM/FORTRAN is that the compiler is available for Xenix and Unix on 80286-based and some 680xx-based computers, so developers porting code to those environments should have little trouble.

The compiler is a solid product, but its compilation and execution speeds are unimpressive. It stops frustratingly short of providing the full complement of extensions that FORTRAN developers need.

Recently, Austec released RM/FORTRAN version 2.4 and the RM Forte programming environment. Due to time constraints, I was unable to review this product fully, but I ran the benchmarks and worked briefly with the Forte environment. (See the text box "RM Forte: Austec's New Programming Environment" on page 194.)

Compile times for version 2.4 compare favorably with those for version 2.11. The Read and Write character data

continued

	Time (in seconds)			Size (in bytes)	
	Compile	Link	Execute	.obj	.exe
Read 1024 36-byte records of unformatted numeric data					
Lahey	2	15	3.02	1053	30256
Microsoft	5	16	0.65	968	24368
RM/FORTRAN	5	12	2.03	1267	32144
Character handling—format 512 records of text					
Lahey	3	21	1.04	1905	139696
Microsoft	6	19	1.26*	1621	130304
RM/FORTRAN	8	13	1.21	2297	135344

*Had to suppress optimizations since the optimized code did not execute correctly.

	Time (in seconds)				Size (in bytes)	
	Compile	Link	Execute	Whetstones	.obj	.exe
Single-precision Whetstones						
Lahey	5	16	76	131	5536	29520
Microsoft	33	21	61	169	7647	30288
RM/FORTRAN	49	13	65	156	9267	36896
Double-precision Whetstones						
Lahey	6	14	81	125	5557	29584
Microsoft	34	21	65	156	7683	30352
RM/FORTRAN	48	13	70	142	9635	37344

	Time (in seconds)				Size (in bytes)	
	Compile	Link	Execute	MFLOPS	.obj	.exe
Single-precision LINPACK:						
Lahey	17	22	1131	.0183	20394	366624
Microsoft	116	26	1002	.0197	25867	363040
RM/FORTRAN	95	19	1094	.0192	29320	374720

About the Benchmarks

Compile, link, and execute times are given in seconds. Timings for the Whetstone benchmark are shown in Whetstones per second × 1000, and timings for the LINPACK benchmark are shown in MFLOPS (millions of floating-point operations per second).

RM Forte: Austec's New Programming Environment

Austec's new menu-driven, multi-window program environment, RM Forte, is an extension of RM/FORTRAN 2.4 designed for the IBM PC, XT, AT, and compatibles. RM Forte operates on groups of files organized as a single project. Forte's menu system begins with the Project Directory, an alphabetized list and short description of each of the projects currently under control of the program.

A source-code project manager handles all the files associated with a project. It knows what files are needed, how to compile and link them, and how to execute the result. When you are finished editing, a single keystroke invokes the project manager, and it handles all the rest. You can do syntax checking on your source code without compiling, again by pressing a single function key. (The function keys are user-definable.)

A project-manager screen tells you the status of your files and even suggests the next step in the development process. You can get an exploded view of file information by pressing a function key. You can set compiler options from another pop-up menu, for individual files or for the entire project.

Forte uses two display modest o view the file you're working on: the Source display and the Listing display. The Source display combines the source file and the change file and shows the current state of your program. The Listing display simulates hard copy, showing the complete program listing of the most recent compilation, with line numbers, errors and warnings, program unit summaries, and all other items that normally appear on an RM/FORTRAN listing.

A split-screen debugging feature lets you stop program execution where you wish so you can examine or change variables and view the source line where the problem occurs. When you toggle the screens, the Run screen displays the output that the program has generated up to that point. When you enter a `GO`, `RUN`, `STEP`, or `NEXT` command, the program displays the Run screen and lets you view execution. Whenever Debug returns program control to you, the program switches to the Listing display of the source program. You can edit your source code whenever execution stops.

You can debug specific files or the entire project, if you wish. Forte features programmable macros, so the full range of editing commands can be combined into keystrokes.

The system requirements for RM Forte are DOS 2.1 or higher, RM/FORTRAN 2.4 or higher, 320K bytes of memory for development and execution, and 192K bytes for RM FORTRAN program development. Two 360K- or 720K-byte disk drives are required, or a single floppy disk drive and a 10-megabyte hard disk drive.

The RM Forte environment is impressive. It's pleasant and efficient to use, and the context-sensitive help system is very effective. However, I couldn't get through the manual's tutorial script without crashing the system.

[Editor's note: *Austec Inc. says a fix for this bug is now available free to owners of RM/FORTRAN 2.4 and will be incorporated into version 2.41. For more information, call Austec's product support at (213) 541-4828.*]

The difficulty with this kind of environment is that, typically, professional software developers must use several different languages, compilers, and assemblers, probably all from different vendors. I would prefer to use my well-worn and heavily customized text editor and a good Make utility to manage most programming projects. Perhaps the day will come when language implementations for a given operating system will be consistent enough to share the same programming environment.

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and formatted data benchmark times for the two versions are identical within a few hundredths of a second. The Floating-Point benchmark indicates that version 2.4's compile time is slightly slower (5 seconds versus 4 seconds), but its execution time is considerably faster (1.76 seconds versus 2.47 seconds).

The Whetstone benchmarks also show an advantage for version 2.4: Single-precision compile times were 30 seconds for version 2.4 versus 49 seconds for version 2.11; double-precision compile times were 32 seconds versus 49 seconds. Version 2.4's performance on the Whetstone benchmark was only slightly better, however (166 single-precision Whetstones versus 156 for version 2.11, and 156 double-precision Whetstones versus 142). The LINPACK benchmark also shows only a slight improvement over version 2.11 (0.0206 MFLOPS for version 2.4 versus 0.0192 MFLOPS for version 2.11). (Note that in the Whetstone and LINPACK benchmarks, higher numbers indicate more iterations, and therefore better performance.)

Benchmarks

For the benchmark tests, I used an 8-MHz IBM PC AT with 3 megabytes of RAM, 50 megabytes of disk storage, and an 80287 math coprocessor running at 6 MHz. The operating system I used was DOS 3.1, and memory was configured as a 256K-byte RAM disk emulator (VDISK was used for all disk I/O).

I also ran the same benchmarks on the same PC AT under DOS 3.1, with DOS running as a task under Unix. The only significant difference between running native DOS and running DOS under Unix involved the compile times. When running under Unix, disk I/O was to the hard disk rather than to a VDISK in memory. Microsoft FORTRAN compiled much more slowly, as it apparently involves a lot of disk activity, placing it behind RM/FORTRAN in compilation speed. For most of the benchmarks, Microsoft FORTRAN took about twice as long to compile as did RM/FORTRAN. However, for the longer benchmarks (Whetstones and LINPACK), Microsoft FORTRAN's and RM/FORTRAN's times were within 10 percent of each other.

Practical Trade-offs

It would be nice to have a single compiler with Lahey's compilation speed, robustness, diagnostics, extensions, production-code debugging, and technical support, with Microsoft's execution speed, documentation, and full-screen debugging interface, and with Austec's multi-architecture support.

Realistically, Lahey FORTRAN is the most efficient and productive FORTRAN development tool for the DOS environment, and I would choose it for most of the code-development cycle. Before the final stages of testing, I would compile with Microsoft FORTRAN to get that last ounce of performance. ■

VIEWS FROM BIX: FORTRAN COMPILERS

fortran/general #84, from David Burleigh.

I have encountered one bug that Lahey's version 2.2 did not fix, but a patch is available from Lahey (two lines to add to the f771.fix file; you can have Lahey dictate it to you over the phone). The bug involves some instances of integer arithmetic on integer*2 variables. Sometimes the sign bit gets set incorrectly—very spooky. Otherwise, I've had no problems with version 2.2 or with SOLD.

fortran/other #47, from Robert Broome.

I recently decided (on the basis of the comments here and a few calls to Lahey) to give the Lahey compiler a try. For what it's worth, I'm quite happy with the decision.

For instance, the very first program I compiled using Lahey turned out to have a minor bug that the Lahey compiler picked up; the Microsoft compiler had been missing it for time immemorial. Also, if you like big-name recommendations, Steve Ciarcia suggested it to a reader in this month's BYTE. As usual, nothing is perfect: I still can't switch completely because a few of my third-party software packages aren't supported. Microsoft FORTRAN still has the edge there. However, the Lahey compiler just feels better, and it certainly compiles faster.

fortran/other #48, from Joel Davis.

I like Lahey, too. (I have used Microsoft FORTRAN, Ryan-MacFarland's Profort, DRI, and Lahey.) It's fast, and its compile-time error messages are superb. Ryan-MacFarland generates slightly faster executable code and has better run-time error performance, but this does not make up for Lahey's superior performance as a developer's code. One word of warning: Unlike MS and DRI, neither Ryan-MacFarland nor Lahey emulates the 8087—it has to be there.

fortran/other #49, from John Leonard.

How is Lahey's run-time library? What kind of object modules does it create? (Can I attach them to Microsoft subroutines?) Does it link with assembly routines?

fortran/other #50, from David Burleigh.

You can link Lahey FORTRAN with assembly language routines easily, according to Lahey, Lattice, or Microsoft linkage conventions. You can link with MS routines that don't require the MS run-time library (i.e., self-contained assembly routines intended to work with MS FORTRAN). Lahey provides some very useful library routines for passing addresses and for issuing DOS and BIOS interrupts.

fortran/other #96, from Daniel Feenberg.

I was a beta test user for Microsoft FORTRAN 4.0. It is a great improvement over 3.2 and 3.31 in many ways. It is the full language, and I believe it compiles and runs faster than it used to. The Whetstone rating is about 20 percent better than Lahey's. It is also less likely to hang without an error message. I still think the Lahey compiler is a much easier compiler to use, and it still compiles several times faster than the Microsoft compiler. It doesn't support NaNs (the way 3.2 did), and I am currently having trouble getting it to read from an installed device (3.2 could), but it is a creditable effort.

fortran/other #109, from Joel Davis.

Indeed, if you have a tree where one branch has a named common group and the highest routine in the branch returns, under the standard, you can lose all the values. The Microsoft bug was of a different character: The COMMONs were stored improperly, and data could get written over other things—your file table, other variables, code, etc. My point was that nothing in the standard forces you to declare named COMMON in the main routine unless you want the variables to be available from that level downward.

fortran/general #174, from Doug Skillins.

I have been using MS-FORTRAN less than I would like to, because of one very irritating problem—Netware and MS-FORTRAN 4.0 are incompatible.

fortran/general #175, from Robert White.

Is it the compiler that is incompatible, the programs it produces, or both? Can you describe the problem in a little more detail? This is important for someone I know who was about to buy it for use on a Novell system. Thanks.

fortran/general #177, from Doug Skillins.

The programs run fine on the net, but the compiler won't compile while the Netware shell is loaded. Therefore, a local hard disk is necessary, as well as the ability to log off the net for long periods of program development.

High C 386

Matt Trask

MetaWare's High C 386 is the first widely available C compiler for the 80386 that runs under MS-DOS. An upgrade of MetaWare's High C product for the 8086/186/286, High C 386 is capable of generating 32-bit op codes and data for the 80386. Currently, it's available for a list price of $895 from MetaWare or from system software companies such as Phar Lap, AI Architects, and Quarterdeck.

High C requires a minimum of 256K bytes of free RAM, so in a typically configured machine (DOS 3.x with resident pop-up utilities and network and other device drivers), you must have about 512K bytes of RAM to run the compiler. Additional memory can speed up the translation process if you configure the compiler for more parse tree buffers.

Although you can fit the compiler onto a 1.2-megabyte floppy disk, I recommend a hard disk. I reviewed High C 386 version 1.3 on a 16-megahertz Intel iSBC 386 AT with 640K bytes of memory and a high-speed hard disk drive (a Maxtor XT-1140).

Installation and the $495 Surprise

High C comes on four 360K-byte disks. The compiler and its attendant utilities and header files are stored in compressed .TAR files. Although the manual has no installation instructions, I completed the installation in about 6 minutes with the fully automated INSTALL.BAT program provided.

After installation is complete, the INSTALL.BAT displays a message suggesting that you can run DEMO.BAT to verify the compiler's operation and show off some of its features. At this point I learned that I could not use the High C compiler without also purchasing Phar Lap's $495 386|ASM/LINK package to get 386|LINK and RUN386 (see my review "386|ASM/ LINK 1.1e" in the August BYTE). You must have 386|LINK and RUN386 to link and execute any object modules that High C generates.

Compiler Operation

You execute the compiler by typing `HC386 <filename>`, where `<filename>` is the name of a C source file. You can use command-line options or directives to control the compiler's operation and toggle compiler-control switches (pragmas). For example, `asm` and `noasm` control the generation of a pseudo-assembly language listing in the listing file. You use `ansi` and `noansi` to suppress the use of MetaWare's language extensions and enforce ANSI compatibility, and `ipath` to specify where the compiler should search for include files. You can also set `ipath` as an environment variable; High C searches the environment if there is no include path on the command line.

Before opening the specified source file, the compiler attempts to open a profile file. This is a sort of meta-header file that can initialize toggles and hold `#define` statements. Profile files are considered optional: the compiler will not complain if it does not find one.

When a syntax error is encountered, most C compilers continue attempting to translate the source code, producing a cascade of meaningless error messages. Of course, these errors disappear when you correct the mistake and recompile. High C 386 is capable of "repairing" many syntax errors (e.g., missing right parentheses, missing semicolons) at compile time, circumventing this problem.

Although High C can generate code for five memory models (small, compact, medium, big, and large), the 386 release provides libraries for only the small model. This should not pose a problem for 80386 developers, since only two memory models are actually available when running the 80386 in protected mode. The small model is a linear address space of 4 gigabytes, typically used by setting the code, data, stack, and extra segment registers to zero. The large model describes the 64-terabyte address space accessed using the 48-bit `PWORD` (pointer word) type addressing. You can implement other models with proper use of segmentation.

The ability to mix data declarations with code statements is one of High C 386's more interesting extensions. It lets you declare data just before the code uses it. You can use this mixing of declarations to initialize a piece of data more than once, such as each time through a loop containing a data declaration.

Other extensions include the use of ranges in case statements (e.g., `case 'A'..'Z' :`) and Pascal-style nesting of functions with full hierarchical name scoping.

Optimization

Optimization is a major attraction of this compiler. High C uses a technique called *common subexpression elimination* to remove extraneous code that repeats some operation already performed. The compiler also uses *cross-jumping* optimization, which modifies code where the target of a jump is also a jump (this might occur in a nested loop).

High C's *tail-merging* optimization is optional; it reduces code size with a small speed penalty by branching back to reuse a previous piece of code when possible. I doubt that this particular type of optimization will be important to designers using a virtual-memory 80386 system, where memory is essentially free and speed is usually considered more important. Optimizations that change the flow of the code can also be confusing to debug.

Register variables and the retention of register contents is another form of optimization provided by High C. The manual obscures this subject, however, because its discussion of register variables assumes that you are developing code on the 8088.

Libraries and Utilities

High C 386's standard I/O and function libraries include your choice of math coprocessor support or emulation. (When High C 386 generates code for a math coprocessor, the compiler assumes that the target device is an 80287, not an 8087.)

MetaWare provides a facility called *packages*—a type of include file with a .CF extension. Among the supplied packages are functions that directly access MS-DOS services, provide sorting algorithms and debugging aids, and have calling-convention interfaces for use with other languages. This deviation from the accepted C practice of naming include files with .H extensions might irk C purists, but the compiler's authors justify it by pointing out that they don't wish to infringe on the name space used by ANSI-standard header files.

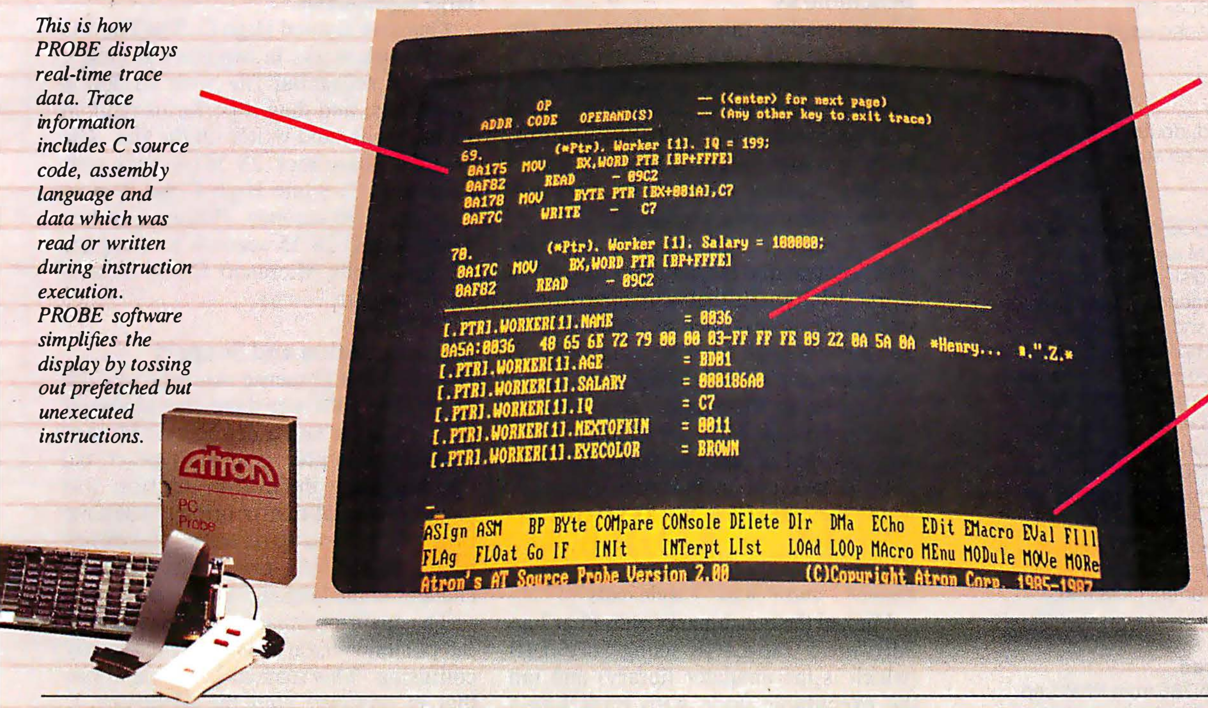
I was also happy to find functions for using C routines as interrupt service routines (ISRs). In particular, the `onexit()` function lets you register functions to be called at exit time, so that you can perform a de-installation of an ISR when you terminate a program with Control-C.

The High C package includes many useful utilities. BD.EXE displays object files in an annotated format that identifies record names and contents. You can also use it in embedded (ROM) applications to detect initialized data that needs to be copied to RAM during initialization. FIND.EXE is a disk searcher; it can scan a disk volume looking for a file or group of files that match a wild-card file spec. CX.EXE compresses and expands files using a 12-bit Lempel-Ziv-Welch file-

continued

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High C 386 version 1.3

Type
C language compiler for the Intel 80386

Company
MetaWare Inc.
903 Pacific Ave., Suite 201
Santa Cruz, CA 95060-4429
(408) 429-6382

Format
Four double-sided, double-density 360K-byte disks in an archived file format

Computer
Runs on any MS-DOS computer with 512K bytes of RAM and either a 1.2-megabyte floppy disk drive or a hard disk drive (recommended); requires an 80386 for testing and executing programs, but compiling and linking does not require an 80386-based computer. Also available as resident and cross compilers for: 386 under DOS using Softguard's VM/Run or Phar Lap's DOS Extender; MC68000 under Unix V and BSD 4.2; VAX under VMS and Unix 4.2; Unix V on AT&T's 6300 Plus; IBM RT PC under Unix 4.2; NS32032 under Unix 4.2; Microport's Unix V/AT; IBM 370 under Unix; Concurrent DOS 286; Xenix/286.

Software Required
386|Link and RUN386 from Phar Lap Software

Documentation
700+-page reference manual in a three-ring binder

Price
$895

Inquiry 899.

compression algorithm (used by the automatic installation procedure). Finally, High C 386 also comes with a set of the more common Unix utilities: `cat`, `ls`, `fgrep`, `uniq`, `tail`, `mv`, and `wc` have separate documentation on disk.

Benchmarks

I benchmarked this compiler using the standard BYTE tests for C compilers. I used the Microsoft C compiler (version 4.0) for comparison. Microsoft C 4.0 does not generate native 80386 code, but, in the absence of any other DOS-based 80386 compilers, I think this comparison will provide a useful evaluation.

As I began compiling the benchmark files, I found that the compiler refused to digest ASCII nulls that were appended to source files transmitted by modem. This was easy enough to solve, but other C compilers don't mind the nulls.

Another problem is a major flaw: I could not run the File I/O benchmark as it was provided because the MetaWare I/O library does not include the `creat()`, `read()`, `write()`, `lseek()`, `open()`, and `close()` functions. I used my editor to change all these calls to comparable `fopen()` and `fread()` style calls.

I linked the benchmarks with Phar Lap Software's 386|LINK using HCE.LIB (which is the emulator library) and ran the executable code with Phar Lap's RUN386 environment. The Microsoft C benchmarks used the MS-LINK linker provided with the 4.0 C compiler.

The results of the benchmarks are surprising: I obtained similar or better performance in many cases with the Microsoft compiler (see table 1). In an effort to explain this, I examined the size of the files each compiler generated (see table 2), and I found that Microsoft C's advantage can be partially attributed to the fact that DOS must load and execute RUN386 before the actual program can load and run. The larger program size of the 80386 versions also increases the load time. This effect should be less noticeable on large applications.

One task favored High C. The File I/O benchmark works in two phases: First it writes a sequential file with 65,000 *X* characters, and then it performs random seeks, reads, and writes on the file. The creation phase took 28.38 seconds with Microsoft C, while High C did it in an amazing 5.90 seconds. However, it then took High C 28.15 seconds to complete the test, while Microsoft C was done in 15.77 seconds.

Table 1: *C benchmarks comparing High C 386 version 1.3 with Microsoft C version 4.0. For a description of these benchmarks, see "Macintosh C Compilers Revisited" by Joel West in the August BYTE. All times are in seconds.*

Benchmark results

	Product	Compile	Link	Run
Fibonacci	High C	15.37	22.66	7.49
	Microsoft C	5.95	3.46	10.11
File I/O	High C	15.20	25.12	34.05
	Microsoft C	8.06	4.78	44.15
Float	High C	14.40	22.70	31.90
	Microsoft C	5.37	5.25	22.80
Savage	High C	14.50	28.71	36.58
	Microsoft C	5.05	5.75	29.43
Sieve	High C	13.80	23.07	1.66
	Microsoft C	5.35	3.77	1.75
Sort	High C	16.75	22.91	2.01
	Microsoft C	8.09	3.81	2.93

Documentation and Support

High C 386's immense manual (over 700 pages in an IBM-size three-ring binder) is both a feature and a detraction. Most of this book was professionally typeset, but the language definition section was printed on a dot-matrix printer. I assume this gives MetaWare some flexibility when the ANSI committee makes changes to the language definition.

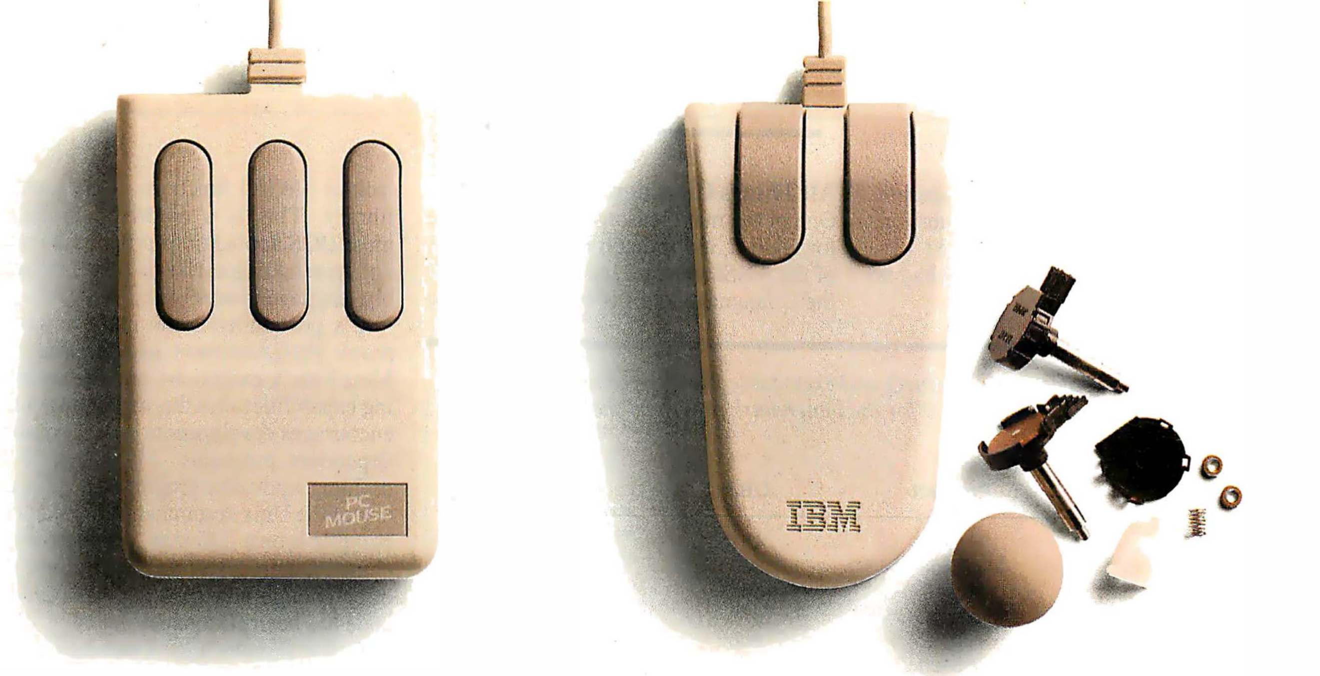
The main complaint that I have with the documentation is that it is extremely confusing. This manual is the same one that is provided with the MetaWare C compilers for the 8086, 8088, and 80286. The only change for the 80386 version is the addition of a short chapter describing the differences in the implementation. Thus, much of the material in the documentation does not apply to the 80386 version. Many of the defaults have been changed, and often I could not be sure that what I was reading was correct. In addition, the library reference was difficult to use: The functions were grouped with their respective header-file definitions rather than in alphabetical order (as in the documentation for the Microsoft and Borland C compilers).

On a more positive note, the language section (though very dry reading) is a welcome addition. It provides a formal definition of the language as implemented by MetaWare. The indexes in each chapter are thorough and very useful, unlike the more typical DOS product manuals.

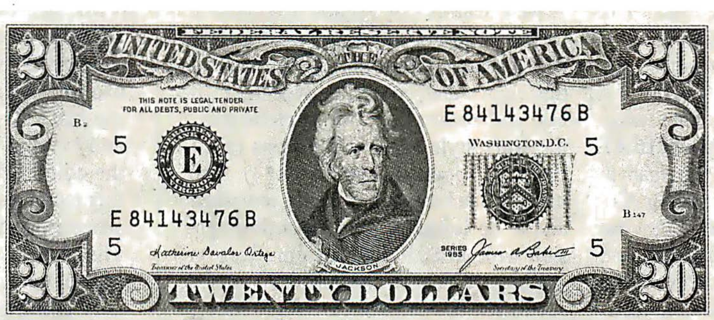
The authors have provided an excellent section on code size minimization. For example, they describe how to prevent the floating-point versions of `printf()` and `scanf()` from being linked (with their attendant code bloat) when you are only using integer arithmetic.

MetaWare's technical support is quite good. Because it is a small company, you wind up talking to one of the product's

continued



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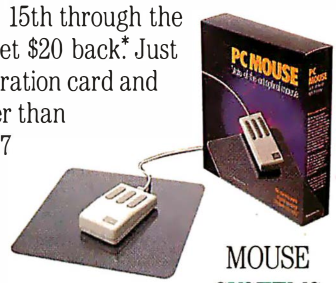
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developers when you call with a question. I asked some rather bizarre questions (meaningful only in the context of a review), and the person I talked to had no problem answering them.

All Things Considered...

One of the main reasons that I don't care for High C 386 is that it follows the letter of the ANSI standard but not the spirit of the C language. This is evidenced by the lack of file I/O functions in the standard library. This is a nontrivial omission; most DOS applications programmers are not up to coding such functions in assembly language themselves.

C's portability is the main reason so many programmers use it. Some of MetaWare's extensions provide interesting capabilities, but this can be a trap that encourages developers to write compiler-dependent programs. My standard for defining a portable program is to take any one of the Unix command sources and recompile it on a different compiler or machine. Other developers have done this often enough now that most nonportable code has been eliminated.

A few months ago, I watched a programmer try to port the SDB (symbolic debugger) user interface to DOS by recompiling it with High C 386. He gave up without ever getting it through the compiler because of problems with symbol redefinitions and run-time limitations imposed by RUN386.

Another shortcoming of this product is that it can only be used with Phar Lap's RUN386. Environments like RUN386 are not necessarily compatible with multitaskers, such as DESQview, Microsoft Windows, and OS/2. Although a few developers will expend the effort to port their applications to RUN386 and VM/Run, most will probably focus their energies on enhancing existing products.

High C 386's error handling could also use improvement. My editor (PC-Vi) lets me start up another COMMAND.COM and execute DOS commands from within the editor. When I tried to compile using this technique, the machine crashed with a heap overflow and a call-chain dump. This was due to insufficient memory, but the compiler did not identify it as such.

All things considered, High C seems to be a product that was rushed to the marketplace so it could claim the title of "only." (For information on High C 386 version 1.4, see the text box at left.) It may be useful to operating-system writers who are avoiding run-time environments by creating their own protected-mode start-ups in assembly language, but I can't recommend this product as an easy path to the 80386 for applications developers.

As times change and true 32-bit operating systems become available, High C 386 will have the advantage of experience. Perhaps then it will evolve into a more usable tool. ■

Matt Trask is a systems programmer at Stellar Computer Inc. (100 Wells Ave., Newton, MA 02159). He was one of the original programmers for Phoenix Technologies' V/pix and Control/386.

Table 2: *A comparison of the object and executable file sizes generated by High C 386 and Microsoft C 4.0 for the benchmark programs shown in table 1. File sizes are in bytes.*

	Product	.OBJ	.EXE
Fibonacci	High C	451	26776
	Microsoft C	500	6480
File I/O	High C	1567	31164
	Microsoft C	1678	10900
Float	High C	906	27036
	Microsoft C	771	19694
Savage	High C	664	31984
	Microsoft C	700	21628
Sieve	High C	496	34896
	Microsoft C	498	6486
Sort	High C	706	30888
	Microsoft C	1042	11118

A Late Note

At the time this article was going to press, MetaWare had begun shipping version 1.4 of High C 386. The company claims that all registered owners of version 1.3 will receive a free update to version 1.4.

I executed the benchmarks for version 1.4 (shown in table A) on a Wyse 3216 AT clone with a 16-MHz 80386, 1 megabyte of interleaved memory, and a Maxtor XT-1140 hard disk. I was unable to run the File I/O benchmark on High C because the Unix-style I/O calls provided with the new release were poorly documented, did not function properly, and were not particularly Unix-compatible. For example, the High C version of the `close()` function is declared as `void`, while the Unix version returns an `int`.

New features of version 1.4 include improved optimization, support for the 80387 math coprocessor, the addition of the `const` and `volatile` type specifiers, and source code for implementing the Unix-style file I/O functions (e.g., `creat()`, `open()`, and `lseek()`). The manual has been significantly reworked and is no longer simply an earlier version with an 80386 addendum. Version 1.4 requires a hard disk and is no longer supported by VM/Run, DOS Extender, or Concurrent DOS 286; however, it does run under DRI's FlexOS 286 and 386.

Table A: *Benchmarks comparing High C version 1.4 with Microsoft C version 4.0. All times are in seconds.*

	Product	Compile	Link	Run
Fibonacci	High C	14.9	22.0	5.7
	Microsoft C	6.3	3.7	8.8
File I/O	High C[1]			
	Microsoft C	8.8	4.5	60.1
Float	High C	14.2	21.5	27.9
	Microsoft C	5.8	5.5	19.9
Savage	High C	14.30	28.1	30.5
	Microsoft C	5.5	6.2	25.7
Sieve	High C	14.2	22.1	1.5
	Microsoft C	5.8	3.8	1.5
Sort	High C	15.8	22.0	2.2
	Microsoft C	8.6	4.2	2.8

[1] I was unable to execute the File I/O benchmark; see text for details.

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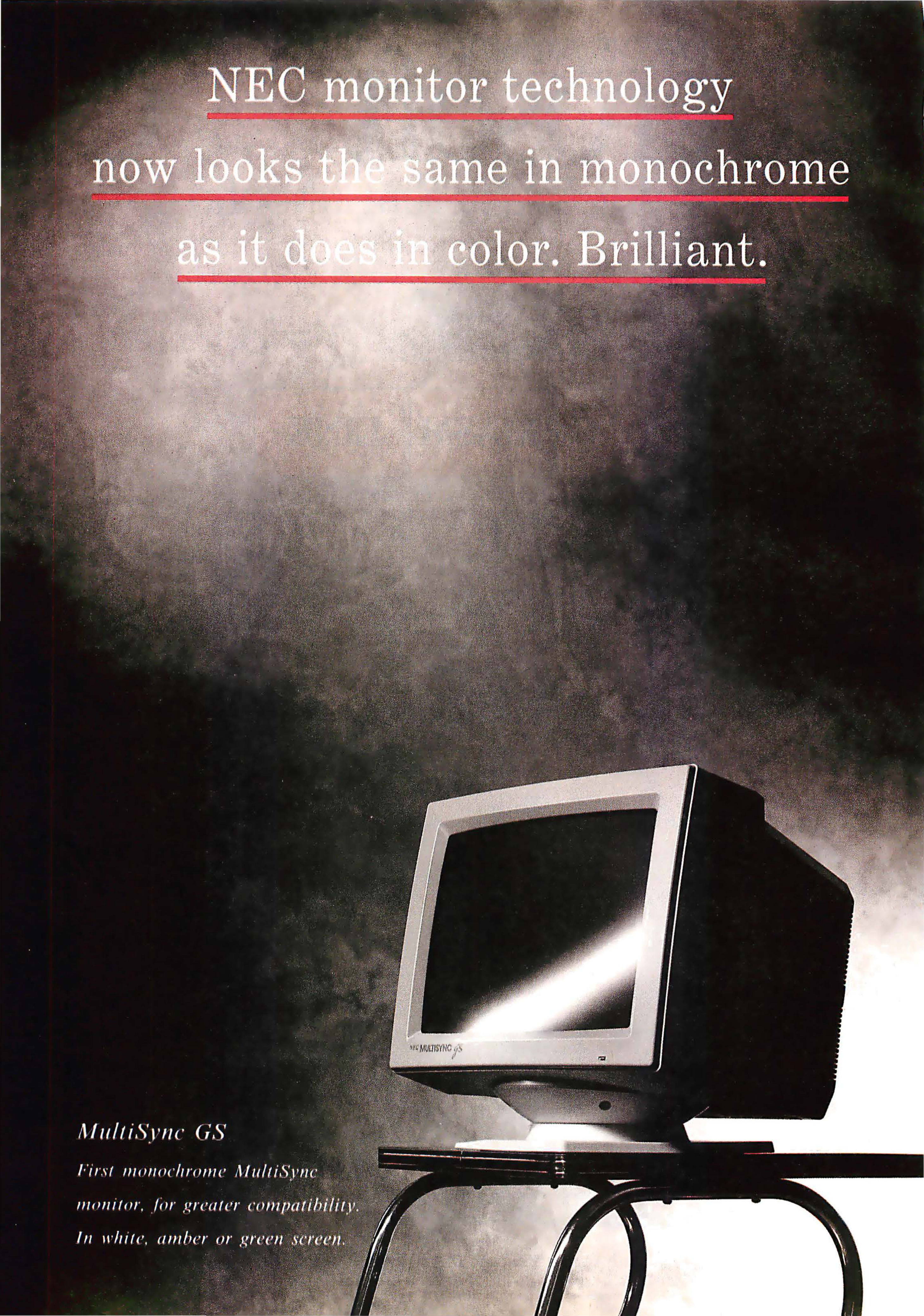
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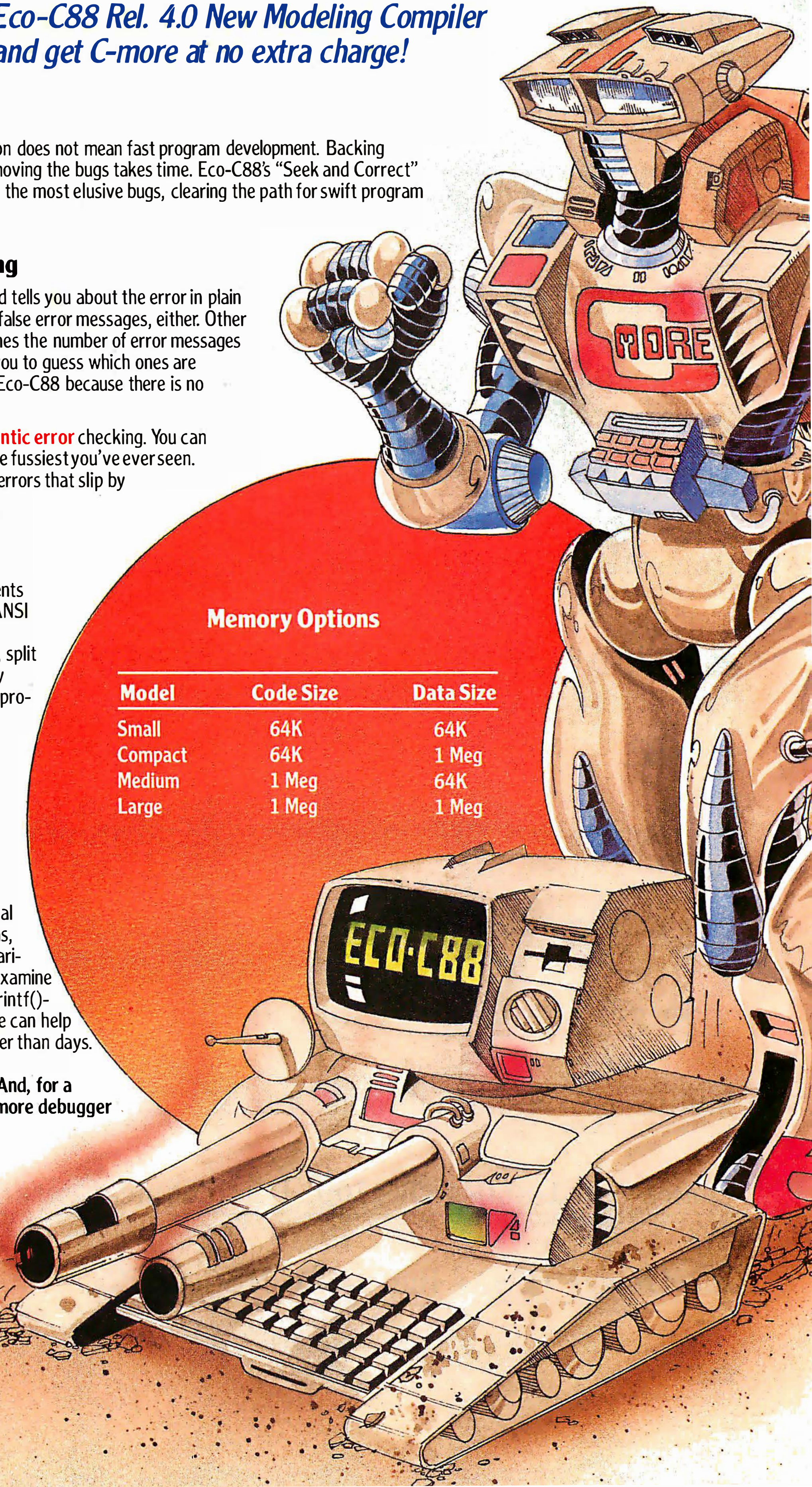
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ANSYS-PC/Linear and MSC/pal 2

Nicholas M. Baran

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ANSYS-PC/Linear, from Swanson Analysis Systems, and MSC/pal 2, from the MacNeal-Schwendler Corporation, are designed for finite-element analysis on the IBM PC. (MSC/pal 2 is also available for the Apple Macintosh.) ANSYS-PC/Linear version 4.2-A3 and MSC/pal 2 version 2.0 each require an IBM PC or compatible (with at least 512K bytes of RAM for ANSYS-PC/Linear and at least 640K bytes for MSC/pal 2), an 8087 numeric coprocessor, a graphics adapter, and at least a 10-megabyte hard disk drive; a 30-megabyte hard disk drive is recommended for large or complex models. ANSYS-PC/Linear is normally leased for $300 per month, but it can be purchased outright for $6400. MSC/pal 2 is priced at $1995.

For this review, I used an IBM PC XT with 640K bytes of RAM, an 8087 math coprocessor, a 20-megabyte hard disk drive, and a CGA to test the two programs.

Overview of Finite-Element Analysis

Finite-element methods are predominantly used by engineers to perform numerical and graphical analyses of the static, dynamic, or thermal behavior of physical systems, structures, and components.

When performing a finite-element analysis, you create a mathematical model of a physical system or structure. The model consists of discrete points called nodes, which are connected together to form finite elements (see figure 1). The finite-element program contains a library of elements from which you select the appropriate elements for the model, depending on the shape of the physical structure (e.g., beam, plate, or solid elements).

The finite-element program then applies the differential equation that represents the physical behavior of the structure and reduces the equation to a set of simultaneous equations that can be solved by the computer. The solution of these equations yields (either directly or by means of minor additional computation) the desired unknown quantities at the nodes, such as deflections, forces, temperatures, or stresses. The values at the nodes are then interpolated to provide results for each finite element in the model.

The most widely used form of finite-element analysis uses the equations of mechanics of materials and structural dynamics to determine the stresses, deflections, and dynamic response of structures subjected to static and dynamic loads. Another common form of finite-element analysis determines the temperature distribution in a component subjected to thermal loading (heat transfer).

In a structural analysis, each node in the finite-element model is characterized by a certain number of "degrees of freedom," or independent motions. A fully unconstrained node in three dimensions may have six degrees of freedom: three rotations and three translations (motion in a straight line). A fully constrained node has zero degrees of freedom and is generally used to represent an attachment point or support.

In a thermal analysis, each node has one degree of freedom, representing a temperature. The computational size of a finite-element analysis is determined by the number of degrees of freedom in the model, since there are as many simultaneous equations as there are degrees of freedom.

Figure 1 shows a plot from MSC/pal 2 of a half-symmetry finite-element model of a steel lifting lug, used for lifting pressure vessels and other heavy objects. In addition to defining the geometry of the model, you also have to specify the type of element (in this case, plate elements), the material properties (steel), and the boundary conditions (restraints and loads) that apply to the model.

The deformed shape of the lug superimposed over the original shape shows the behavior (exaggerated for clarity) of the lug when it is subjected to a vertical lifting load. Note that only half of the lug is modeled; this is because the loading in this example is symmetrical about the vertical axis of the lug. Taking advantage of symmetry lets you reduce processing time and modeling complexity.

Figure 2 shows a stress-contour plot for the lifting lug, generated in MSC/pal 2. The stress-contour plot provides a graphical representation of the stress variation in the model. Each continuous line or contour within the outline of the model represents a constant stress value. By counting contour lines starting from the outer boundaries of the model (where the stress is small or zero), you can estimate the stress value at any location on the model.

In the lug example, the maximum stress occurs near the horizontal axis of the circular portion of the lug. Typically, an engineer compares the maximum stress, as determined by the analysis, to code requirements to determine if the part is structurally adequate for its intended use. [Editor's note: *For more detailed discussion, see the article "Structural Analysis" in the July 1986 BYTE and the references at the end of this article.*]

ANSYS-PC/Linear

As its name indicates, ANSYS-PC/Linear supports only linear, elastic analysis

continued

Nicholas M. Baran is a BYTE associate technical editor and is the author of Finite Element Analysis on Microcomputers *(McGraw-Hill, 1987). He can be reached at BYTE, 425 Battery St., San Francisco, CA 94111, or on BIX as "nickbaran."*

(i.e., analysis of structures not subjected to permanent deformation). ANSYS-PC/Linear's lease price of $300 per month includes version upgrades and free technical support. The purchase price of $6400 includes one year of technical support and automatic version upgrades. However, after the first year, technical support and version upgrades are available only at additional cost. (Upgrade prices vary, depending on the extent of the upgrade.) Swanson Analysis discourages the outright purchase option.

ANSYS-PC/Linear comes on nine 5¼-inch disks and takes about an hour to install using the provided installation program. You also have to install a security device (included with the package) in the parallel port of the computer. The device is installed in-line with the printer cable and does not affect the printer's operation. However, the security device that came with my package was defective and had to be replaced.

ANSYS-PC/Linear currently supports eight graphics drivers, including the Color Graphics, Enhanced Graphics, Hercules, and Professional Graphics adapters. It also supports memory drivers for 512K bytes, 640K bytes, and expanded memory (2 megabytes is recommended). You must execute the graphics and memory driver commands, which can be included in a batch file, before running ANSYS.

The package lets you perform static and dynamic (natural-frequency and response-spectrum) analyses of structures and components using two- and three-dimensional truss and beam elements, and plate, axisymmetric, or solid elements. Generalized stiffness and mass elements are also available, along with a spring element. A major strength of ANSYS-PC/Linear is its element library, which provides elements suitable for most types of elastic analysis, including thermal-stress analysis.

ANSYS-PC/Linear is a reduced version of the mainframe ANSYS code. Its major difference from the mainframe code is its reduced number of available element types and analysis options. While the mainframe code supports over 60 element types and seven analysis options, ANSYS-PC/Linear supports 13 element types and two analysis options. ANSYS-PC/Linear is fully compatible with the ANSYS mainframe code and also with ANSYS-PC/Thermal, Swanson's heat-transfer finite-element program. ANSYS-PC/Linear accepts nodal temperatures for performing thermal stress analysis and can read files generated in ANSYS-PC/Thermal.

ANSYS uses a wave-front equation solver, which solves the simultaneous equations in internal memory but swaps terms to and from disk. Because of this technique, ANSYS-PC/Linear supports theoretically unlimited problem sizes. Practically, however, problem sizes are limited by the microcomputer's hard disk storage capacity and by the amount of time you are willing to wait for a solution. For medium to large problems (those with 1000 or more degrees of freedom), a 30-megabyte hard disk drive is strongly recommended. A problem with 2000 degrees of freedom will take about an hour to solve with ANSYS on an IBM PC.

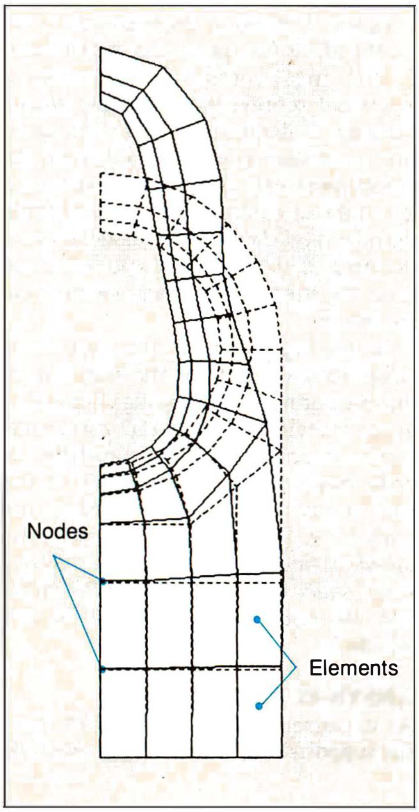


Figure 1: *A half-symmetry finite-element model of a steel lifting lug, used for lifting pressure vessels and other heavy objects, generated in MSC/pal 2.*

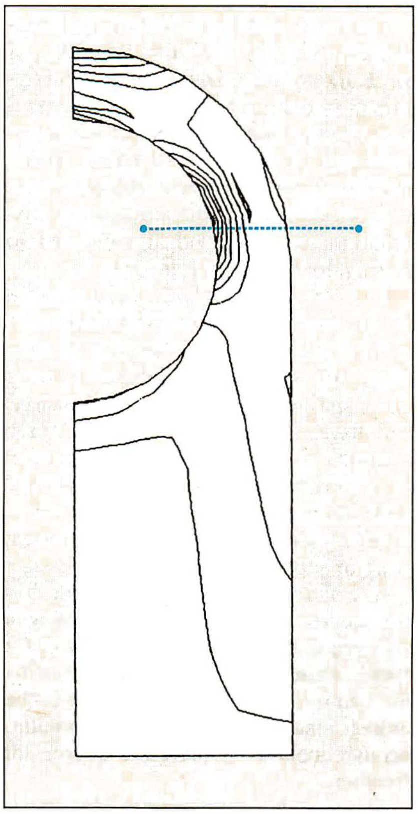


Figure 2: *A stress-contour plot for the lifting lug in figure 1, generated in MSC/pal 2. The maximum stress occurs near the horizontal axis of the circular portion of the lug.*

The Modules

ANSYS-PC/Linear has three main modules. PREP7 is a preprocessor for generating models, applied loads, and boundary conditions. You can also plot and view models from within PREP7. ANSYS is the main number-crunching part of the system, and POST is a postprocessor for generating stress-contour plots, deflected shapes, stress combinations, and so on. A fourth module, DISPLAY, lets you display previously compiled plot files in a sequence or slide-show format.

Each of these modules is contained in files that you execute separately from the DOS prompt, specifying input and output files. For example, the command `PREP <MDL.IN>MDL.OUT` loads the PREP7 module, which then executes the commands stored in the input file MDL.IN. Output is written to the output file MDL.OUT.

ANSYS-PC/Linear is an interactive program, so you can enter commands interactively while you're in PREP7 or POST, to generate the finite-element model or to issue postprocessing commands. The program has a complete but very terse set of commands for defining and plotting finite-element models. While in interactive mode, you can call up on-line help documentation that describes the function of each command.

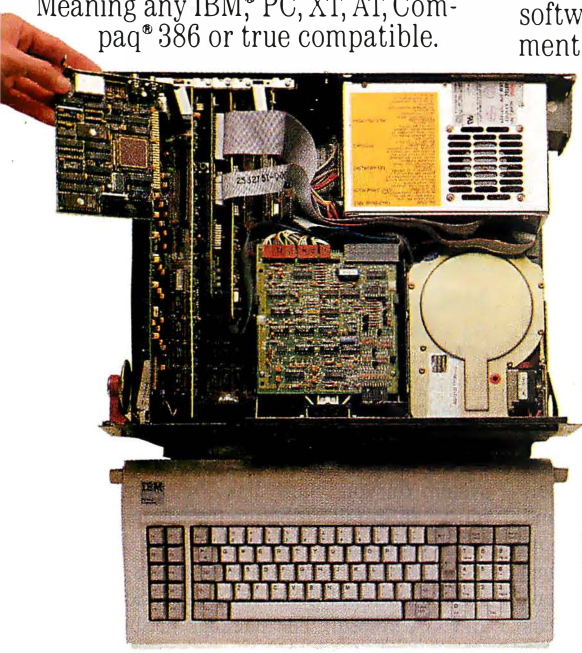
ANSYS-PC/Linear includes commands for generating node and element patterns and for filling evenly spaced nodes between previously defined nodes. You specify boundary conditions as enforced displacements, concentrated or distributed forces, pressures, or nodal temperatures. ANSYS-PC/Linear also includes commands for automatically calculating intersection points, defining

continued

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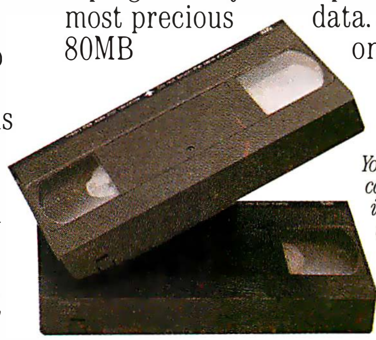
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ANSYS-PC/Linear version 4.2-A3

Type
Finite-element analysis program

Company
Swanson Analysis Systems Inc.
P.O. Box 65
Johnson Rd.
Houston, PA 15342
(412) 746-3304

Format
Nine 5¼-inch disks

Language
FORTRAN

Hardware Required
IBM PC, XT, AT, or compatible with a minimum of 512K bytes of RAM, Intel 8087/80287 math coprocessor, 10-megabyte hard disk, CGA, EGA, IBM PGA, Hercules, or VMI1024 graphics adapter, and parallel printer port

Software Required
DOS 2.1 or higher

Documentation
One three-ring loose-leaf binder, approximately 200 pages

Price
$300-per-month lease or $6400 purchase

Inquiry 901.

MSC/pal 2 version 2.0

Type
Finite-element analysis program

Company
MacNeal-Schwendler Corp.
815 Colorado Blvd.
Los Angeles, CA 90041
(213) 258-9111

Format
Ten 5¼-inch disks

Language
FORTRAN

Hardware Required
IBM PC or compatible with 640K bytes of RAM, 10-megabyte hard disk, Intel 8087 math coprocessor, CGA or EGA, and IBM graphics printer or compatible

Software Required
DOS 2.1 or higher

Documentation
Reference manual, about 200 pages; user's manual, about 200 pages; examples guide, about 100 pages

Price
$1995

Inquiry 902.

symmetrical boundary conditions, and generating local coordinate systems.

One of the more powerful features of ANSYS-PC/Linear is its ability to work with subsets of defined nodes and to define data tables for material and geometric properties.

A disadvantage of the interactive mode is that correcting errors is difficult. As you enter commands interactively, ANSYS-PC/Linear stores the model definition in a temporary scratch file. If you accidentally specify incorrect coordinates or node or element numbers, you have to undo these mistakes by issuing an overriding command. This process can quickly become confusing (since you can lose track of where you have made errors) and cumbersome (since you have to delete previously defined commands from the model definition).

The interactive mode is most suitable for issuing a few on-line commands to obtain a plot or a small listing. For creating a moderate-size finite-element model, I found it much easier to prepare the input file using a text editor and then to run PREP7 in batch mode using my input file.

Once you have successfully generated a model in PREP7, you simply execute the analysis by issuing the ANSYS command at the DOS prompt. ANSYS then uses the binary input file created by PREP7 when you defined your model. One problem is that both PREP7 and ANSYS overwrite existing input and output files each time you perform another analysis. You therefore have to use a separate subdirectory for each new analysis if you want to save previous ones.

The ANSYS postprocessor, POST, provides a comprehensive set of commands for manipulating and plotting the output data from your analysis. You can sort nodal and element values, work with subsets, and create a virtually unlimited range of plots of the model. Superimposed shapes are supported, along with plot rotation, zoom, and optional node and element numbering.

POST has very powerful computational capabilities for manipulating the results of your analysis. For example, you can combine load cases from separate analyses or check the analysis against maximum calculated values. The procedures for this type of work are not straightforward, however, because they require file manipulations (such as renaming scratch files) that could easily result in mistakes.

One deficiency in POST is that it can plot stress-contour plots only in shades of color. Line-contour plots, like the one shown in figure 2, are not available in ANSYS-PC/Linear. If all you have is a black-and-white printer or plotter, the contour plots are difficult to interpret on the printed reports. To print plots with ANSYS-PC/Linear, you use the DOS Print Screen function.

The ANSYS-PC/Linear manual comes in a three-ring loose-leaf binder and does not include an index. The material is organized according to groups of commands. I found myself constantly flipping through the manual trying to find what I was looking for. An index listing each command would be extremely helpful. The manual includes some example problems, which are helpful, but it illustrates only very simple applications. Learning to use the more advanced features of ANSYS-PC/Linear to create complex models is, unfortunately, a process of trial and error.

Overall, ANSYS-PC/Linear is a powerful and flexible finite-element program. However, it is difficult to learn because it suffers from poorly organized documentation with terse explanations of the command functions.

MSC/pal 2

As with ANSYS-PC/Linear, the makers of MSC/pal 2 recommend that you have a 30-megabyte hard disk drive for large, complex analyses. MSC/pal 2 is copy-protected, using the SuperLOK software-protection system. You can install the system on your hard disk, but then you must "de-install" it before the master disk will let you install it on another hard disk.

MSC/pal 2 comes on seven disks, plus three additional disks for installation on an EGA system. The package includes a program that assists you in performing the installation. As with ANSYS-PC/Linear, installation takes about an hour.

MSC/pal 2 uses an equation solver that works only with internal memory and thus is limited to problems of roughly 1000 to 2000 degrees of freedom, depending on the type of analysis. MSC/pal 2 supports two- and three-dimensional truss and beam elements, a curved-beam element, quadrilateral and triangular plate elements (along with shear-panel, discrete-mass, spring, and damper elements), and a generalized stiffness element.

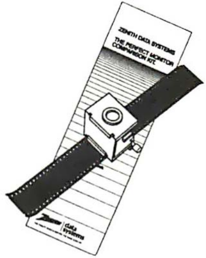
The program performs static analysis and dynamic natural-frequency and transient-response analysis. It does not support solid and axisymmetric elements,

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thermal-stress analysis, or response-spectrum analysis. Although MSC/pal 2 is not a derivative of the mainframe program MSC-NASTRAN, an option is provided for translating MSC/pal 2 data files to NASTRAN format.

MSC/pal 2 consists of five separate modules, which you execute from the DOS prompt: PAL2, for generating the finite-element model; STAT2, for static analysis; DYNA2, for dynamic analysis; VIEW2, for obtaining plots of the model; and XY-PLOT2, for graphing numerical results.

Several additional, more specialized modules are also included. ADCAP2 converts files to NASTRAN and generates lists of system equations and data sets. PALPREP2 is an interactive preprocessor for generating simple beam or plate models. ADCAD2 converts files from AutoCAD's DXF file format. Finally, REPLAY2 saves plot files and displays them in a slide-show format.

All modules in MSC/pal 2 are menu-driven. You are prompted either to make a menu choice or to enter a value in a specified field. All input to MSC/pal 2 must be in uppercase letters.

Working with MSC/pal 2

Unlike ANSYS-PC/Linear, MSC/pal 2 provides no interactive modeling capability. The first step in an analysis is to use a text editor to write a batch file containing the commands for creating the finite-element model.

The command syntax in MSC/pal 2 is more English-like than the command language of ANSYS-PC/Linear. Commands are included for generating node and element patterns and for filling in nodes between previously defined nodes. Boundary conditions are input as concentrated or distributed forces, pressures, and enforced displacements. MSC/pal 2 does not include commands for automatically specifying symmetrical boundary conditions or local coordinate systems, or for calculating intersection points.

Once you have written the batch file, you can check for errors by using VIEW2 to create a plot of the model. MSC/pal 2's menu structure makes the VIEW2 module very easy to use, allowing you flexibility in creating plots of your model. You can rotate, shrink, or expand your plot as needed. You can display element and node numbers, or just an outline of the model. A nice feature is that you can generate either shaded-color or line-contour plots. You then use PAL2 to generate the finite-element model.

The XYPLOT2 module is convenient for graphing numerical relationships, like acceleration versus time. (ANSYS-PC/Linear does not support numerical graphs.) You use the DOS Print Screen function to print plots from VIEW2 or XYPLOT2.

You use the STAT2 and DYNA2 modules to perform static and dynamic analyses, respectively. Separate, short batch files are needed to specify loads and boundary conditions for the STAT2 or DYNA2 modules. Since MSC/pal 2 also overwrites output files, you must use separate subdirectories if you want to save previous analysis files.

In general, the modules in MSC/pal 2 are easy to use, although the program provides no on-line help, and in many instances, it locks into a prompt field until you enter an acceptable value. For new users, this is very frustrating. I had to reboot several times while learning the program just to escape from an insistent menu prompt.

The MSC/pal 2 documentation comes in three binders, consisting of a reference manual, a user's manual, and an examples guide. The manuals are thorough and provide a good deal more introductory material than does the ANSYS-PC/Linear manual. The manuals include a sparse index, and I found myself fre-

continued

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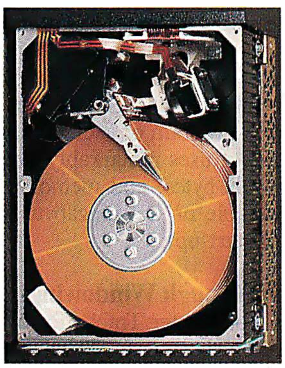
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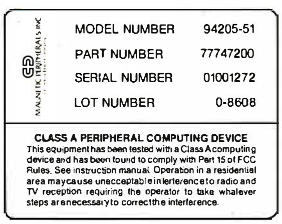
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quently switching from one manual to the other, looking for the information I needed.

Which One Should You Buy?

Except for the limited problem size, the lack of an axisymmetric or solid element, and the lack of thermal-stress analysis, MSC/pal 2 is well-suited for many typical linear elastic problems. Problem sizes in ANSYS-PC/Linear, on the other hand, are limited only by your computer's hard disk space. ANSYS-PC/Linear supports thermal-stress analysis and both solid and axisymmetric elements.

Performance of ANSYS-PC/Linear and MSC/pal 2 is about the same. The lifting-lug problem, which is only 114 degrees of freedom, took about 8 minutes to run with either program on an IBM PC. A model containing 2000 degrees of freedom takes about an hour to analyze with either program running on an IBM PC.

At $1995, MSC/pal 2 is considerably less expensive than ANSYS-PC/Linear's $300-per-month lease or $6400 purchase price. Like ANSYS-PC/Linear, MSC/pal 2 is continually upgraded to include new features. The MacNeal-Schwendler Corporation is planning to include larger problem sizes, thermal-stress analysis, and solid and axisymmetric elements in a version to be announced later this year. If you are willing to wait for those features, or if you can do without them, MSC/pal 2 is an excellent choice for everyday linear analysis work.

Currently, ANSYS-PC/Linear is more powerful and flexible than MSC/pal 2. It has a larger element library, and its postprocessor offers superior computational and output capabilities. ANSYS-PC/Linear's compatibility with the mainframe version and heat-transfer program may be a compelling feature for some users. However, its high price and the steep learning curve caused by its poorly organized documentation are major drawbacks. Swanson Analysis has stated that it will be releasing a new version at the end of this year. Pricing is not yet available.

Both products are backed by reputable vendors with many years of experience. Both vendors offer training courses and ongoing technical support. If you want reliable, accurate results and solid technical support, you will not regret purchasing either of these products. ■

BIBLIOGRAPHY

Baran, N. M. *Finite Element Analysis on Microcomputers*. New York: McGraw-Hill, 1987.

Cook, R. D. *Concepts and Applications of Finite Element Analysis*, 2nd ed. New York: John Wiley & Sons, 1981.

Master Tracks Pro MIDI Sequencer

Donald Swearingen

The Apple Macintosh is one of the most capable microcomputers being used in music systems. It can control music synthesizers, drum interfaces, and music keyboards, all through the industry-standard MIDI (short for musical instrument digital interface) bus.

With the proper software, called a *sequencer*, your computer can be a control center in which you not only store and play back your music performances but also manipulate them in some very powerful ways. Using one of several adapters and an industry-standard MIDI bus, you can interconnect countless electronic musical instruments, such as synthesizers, drum interfaces, and keyboards.

Most sequencers adopt as their model the multitrack analog tape recorder, a machine that allows independent recording of several (usually four or more) parallel audio tracks on magnetic tape. The program I'm reviewing, Passport's Master Tracks Pro MIDI Sequencer version 1.10, is an excellent sequencer.

Master Tracks Pro sells for $349.95. It conforms to the standard Macintosh user interface and works with any of the many 1-megahertz MIDIs available for the Macintosh; I tested Master Tracks Pro with Opcode Systems' Studio Plus Interface. For a program of such comprehensive scope, it uses remarkably little disk space (140K bytes) and memory (774K bytes available on a 1-megabyte Macintosh after start-up).

Control Through Windowing

The basis of Master Tracks Pro's power and usability is its use of multiple windows to control and display the recording, editing, and playback of MIDI data. These include a Sequencer window, where up to 64 tracks of MIDI data can be managed; a Song Editor window, where multiple tracks are displayed in a graphic format for editing at the measure level; a Step Editor window, for high-resolution graphics editing of MIDI data within a single track; a Conductor window, for measure-by-measure tempo management; and a Transport window, for control of both the recording and playback processes.

At boot-up, all windows are on-screen, with the Sequencer and Transport windows in the foreground. The Sequencer window lets you select a track for solo performance, and it can indicate that a track's data is to be "looped" on playback for continuous replay.

After you've selected a track from the Sequencer window for recording, you use the Transport window to control the recording and playback process. The Transport window resembles a tape recorder's controls, with "buttons" for start, stop, record, rewind, pause, and fast forward/reverse. Also included are switches for automatic rewind, MIDI patch-through (with optional channel reassignment), metronome and count-in control, and activation of play/record from an attached MIDI keyboard.

During recording and playback, the Transport window displays the current position in the song in measures, beats, and clocks (240 clocks per beat), and the actual elapsed time, in minutes and seconds, since recording or playback started. Once you have recorded them, you can save tracks on disk using the standard Macintosh pull-down File menu.

The Song Editor lets you edit one or more tracks at the measure level. The display uses boxes to represent individual measures within each track. If MIDI data is present in a given measure, the box is black; otherwise, it is empty. To select a region for editing, you use the standard Macintosh method of pointing to one corner of the region and click-dragging to the opposite corner. You can then select an operation to be performed on the track data within the region.

To duplicate a multitrack region, you simply copy it to the Clipboard, click on the place you wish to insert a copy, and paste. If you don't want to overwrite the data already present, you can select merge instead of paste, and the new data will be merged with whatever data was already present in the target region. If you don't like what you have done, both cut and paste operations are undo-able (as are most other transformations), so you need not live with your mistakes. This makes it easy to test possible changes without committing to them.

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Master Tracks Pro MIDI Sequencer version 1.10

Type
MIDI sequencer program

Company
Passport Designs Inc.
625 Miramontes St., #103
Half Moon Bay, CA 94109
(415) 726-0280

Format
One 3½-inch floppy disk

Language
C and assembly language

Computer
Apple Macintosh with at least 512K bytes of memory

Interface
Any passive 1-MHz MIDI for the Macintosh

Documentation
120-page user's manual in book-size three-ring binder

Price
$349.95

Inquiry 903.

just move track data around, and Master Tracks Pro provides many musically useful editing functions to accommodate your needs. The Change menu lets you apply one of several possible transformations to a highlighted region. Included are functions to modify MIDI channel, velocity, and continuous data; to quantize and humanize (i.e., apply a random factor to) event times; and to transpose pitch values. If you don't want to apply changes to all the data in a region, you can use the Strip Data function to first isolate the desired data and then cut or copy information from a track based on combinations of various criteria: by MIDI channel, MIDI data type, controller number, or note range.

If you want to hear the results of your changes without leaving the Song Editor, you can press the space bar on the Macintosh's keyboard to start and stop the playback process, selecting the starting point by clicking on a measure in the Song Editor display. During playback, a vertical black bar moves through the display, indicating the measure currently being performed. This visual feedback, which is also available in the Step Editor, is a very valuable editing feature, allowing you to see the measures or notes that you are hearing.

If you need more editing precision than the Song Editor provides, you can use the Step Editor to edit a track at the note level. The Step Editor displays a track's notes graphically in a horizontal piano-roll format, and you can use special keys to zoom in and out, displaying from ½ to 12 measures on-screen at once. All the editing operations available in the Song Editor level are applicable to regions selected in the Step Editor, and you can enter new notes using either the mouse or an attached MIDI keyboard.

Several associated windows used for editing nonnote MIDI data use the Step Editor's display format. These include Pitch Bend, the modulation wheel, and MIDI program changes. For example, if you are editing measure 34 in the Step Editor, you can select the Pitch Bend window from the Windows menu and easily modify the Pitch Bend data that's present.

Advanced Features

Master Tracks Pro has a number of other features that make it even more attractive to a MIDI musician. A Conductor Track lets you specify individual tempo and time-signature settings for each measure in the piece. The Fit Time function under the Change menu lets you adjust the playback speed of a selected region to a specified length—say, to change a section's length from 1 minute to 1 minute, 10 seconds. You can also transfer MIDI-system exclusive data from attached MIDI devices and save it on disk for later retrieval and downloading; this makes it easy, for example, to catalog synthesizer sound or voice data associated with your piece.

You can map certain keys of your MIDI keyboard to control the sequencer's Transport and Step Input functions so that you can operate without the Mac's mouse or keyboard. If you want to discard certain types of MIDI data, you can use the Record Filter to specify which types of data are to be recorded and which are to be rejected. (You can, for example, discard aftertouch data, the MIDI data that tells how hard a key is being held down. Such data takes up a lot of space and is usually not used.)

If you are working with film, or if you need precise timing control when recording your tracks on tape, Master Tracks Pro is compatible, through its use of MIDI Song Pointer, with SMPTE (Society of Motion Picture and Television Engineers) codes that allow you to synchronize what you're playing to a given piece of video. Finally, you can save your working setup, including the screen layout, filter settings, and other information, independently of the actual track data.

Minor Problems

If I had to find fault with Master Tracks Pro, it would have to be largely in terms of a wish list of useful functions not provided in this release. For instance, I would like to see many more functions under the Change menu. Two obvious enhancements would be event-time reversal (playing music backward) and pitch inversion, but the possibilities here are really limitless.

Another problem is that the only way to view individual note velocities (representing loudness) is by double-clicking on the individual note in the Step Editor. Some kind of graphic display of this important musical parameter would be most helpful.

Other minor irritations include the fact that the tracks loop on playback only if you start playback from the beginning of the piece. Also, there is no easy way to find out what types of nonnote MIDI data are present in a track. The Song Editor indicates the presence of nonnote data in a measure, but if you don't already know what type of data you're looking for, you must laboriously search for the actual data using one of the special editing windows. I think you should be able to point to a measure and get a display of the types of data present in the measure (e.g., notes, pitch bend, and program changes).

Finally, I would like a stored recording to include some kind of text field that would let me keep some notes about it. This is such a simple feature to implement that I wonder why no one has yet offered it in a MIDI sequencer.

Even with its forgivable shortcomings, Master Tracks Pro is a powerful new editor for musical data whose visual orientation makes it a pleasure to use. Its competitive price makes it a strong bet to overtake many of its predecessors. I think that this package is sure to become the new standard by which MIDI sequencers are judged. ■

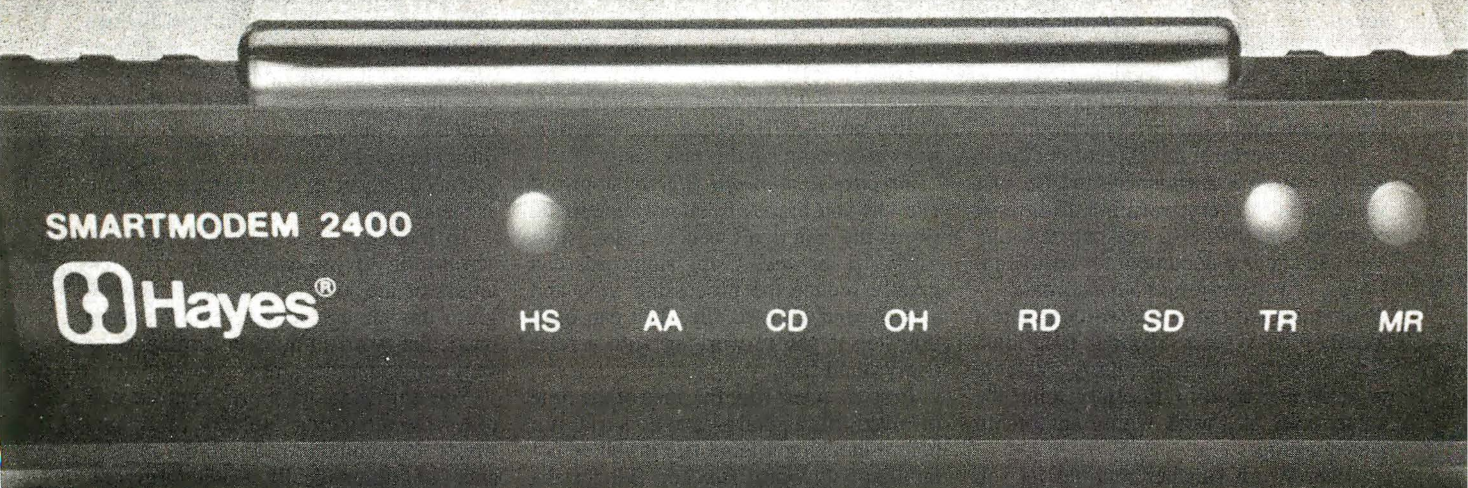
Donald Swearingen (2261 Market St., Box 289, San Francisco, CA 94114) is a composer and programmer. He has been involved in computer-aided electronic music for over 11 years.

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WordCruncher

Rubin Rabinovitz

WordCruncher version 4.1 ($299) from Electronic Text Corp. (ETC) is a powerful text-indexing and retrieval program for the IBM PC, XT, AT, and compatibles. It requires 512K bytes of RAM (ETC recommends 640K bytes for improved speed), at least two floppy disk drives (a hard disk drive is recommended), and MS-DOS 2.1 or higher. I tested WordCruncher on an IBM PC with 640K bytes of RAM and a 20-megabyte hard disk drive running under MS-DOS 2.1.

Originally called the BYU Concordance Program (because it was written at Brigham Young University), WordCruncher has two main programs: IndexETC, for indexing text files, and ViewETC, for retrieving data from the indexed files. WordCruncher performs functions that formerly were possible only with mainframe computer programs developed at academic text-processing centers.

Word Crunching

Text retrieval—also known as word crunching and concordance making—involves indexing the words in electronic text files and then providing various types of access to the indexed data. The simplest kind of text retrieval consists of finding the location of a word or series of words in a file.

Most word processors have this global-search capability. Some word processors can also perform searches involving logical operators, such as AND and OR. This type of search can discover, for example, whether the combinations William Smith, Bill Smith, or B. Smith and John Jones or J. Jones occur near one another in a given file. You might use such a search in examining legal testimony to find out whether these two people ever met or communicated with each other.

You can perform this type of operation easily with WordCruncher, and because you can index every word in a file, more complex routines also become feasible. You can check a document for redundant words, or you can create a concordance—an alphabetical list of the words in a text together with their original locations. Concordances are particularly valuable in analyzing style or in establishing the authenticity of a work whose authorship is in question.

Other WordCruncher routines let you prepare specialized concordances, search for groups of related words, conduct word-frequency counts, compile dictionaries and thesauri, and create reversed-word lists (used for studying words with similar suffixes, such as nouns ending in *-ology* or verbs ending in *-ed* or *-ing*).

Before You Start

Before you can start retrieving your indexed data, you must perform some preliminary tasks.

Enter data: Unless the original text you're working with is already in electronic form, you need to key it into a computer, either manually or with an optical character reader. You also need to remove hyphens from the text, so the halves of split words won't be indexed separately. These and several subsequent steps must be done with your word processor or text editor: WordCruncher doesn't include an editing program. (If you use WordPerfect, you will have an easier time, because WordCruncher is compatible with WordPerfect library routines.)

Enter reference codes: You must add the symbols that WordCruncher uses to recognize numbered blocks of text, such as chapters, sections, pages, paragraphs, verses, or lines. If your file contains page numbers, you can use a search-and-replace routine to prefix them with WordCruncher codes. With long files, a word processor with macro capability is advisable to make repetitive referencing tasks easier.

Prepare an ASCII file: Most word processors use control characters that normally are invisible on the screen. Since WordCruncher works with pure ASCII files—that is, text files that are free of these control characters—you must remove them. Most word processors that utilize non-ASCII formats provide routines to accomplish this task easily.

Prepare a stopword file: A stopword file lets you bypass frequently recurring words that you don't want to index, such as *the, a,* or *and.* Using stopwords can greatly reduce the processing time and size of your indexed file. You can omit this step if you're working with a relatively small file.

Prepare a test file: Because of the time involved, it's a good idea to do a trial run before indexing a large file if you're not familiar with WordCruncher. (I indexed a 10K-byte file in about 2 minutes.) Carrying out the final steps with a small test file lets you know whether you've done the referencing properly.

Choose a sorting sequence: WordCruncher's IndexETC program comes with standard sorting sequences for texts in English, French, German, and Spanish. If you wish, you can create variants in the default sequences to change the order in which alphabetic characters are sorted, or you can design a new sorting sequence to meet any special needs.

Index the file: During the indexing process, IndexETC adds special codes to your data, sorts it, and performs other tasks, while a screen display shows you how much of the process has been completed and whether any referencing errors have been detected. When the indexing is finished, the screen displays such information as the total number of words in your file, the number of unique words, and the file size in bytes.

Correct errors: If the program finds any referencing errors, such as invalid reference codes, you can display a series of error messages at the end of the indexing process to help with your corrections. If your file has few or no errors, you can start the text-retrieval routines.

A View Master

Once your file is indexed, you can load the ViewETC program to look at the indexed output. This is where WordCruncher comes into its own; the viewing routines are easy to use and very fast. After choosing the file you want to work with, you see an alphabetical listing of its unique words (keywords) and a word-frequency number. Such listings are useful: For example, if you're trying to prove that Shakespeare was the author of a recently discovered play, comparisons of its word-frequency lists with those from *Hamlet* or *King Lear* might provide valuable evidence.

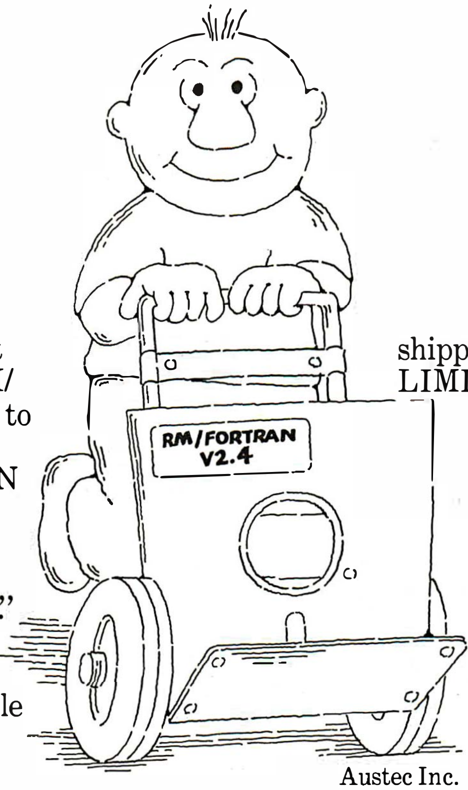
If you want information about a particular word or phrase, you can get listings of all its occurrences, together with their locations in the text. In addition, you can examine these words in their original contexts. Thus, if you want to see all the lines spoken by one character in a play, you need only enter that character's name as the keyword.

To look at a new keyword, you can scroll to it, or you can type the first few letters of the word. As soon as the program has enough letters to recognize a particular word, it quickly displays it—a very convenient feature.

You can generate more complex displays by retrieving clusters of related words. You could look for all the appearances of grammatically related forms of a

continued

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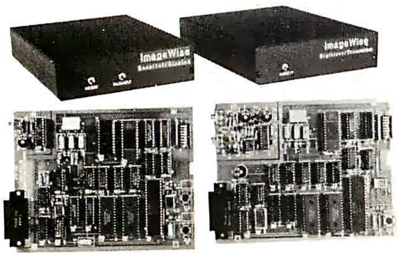
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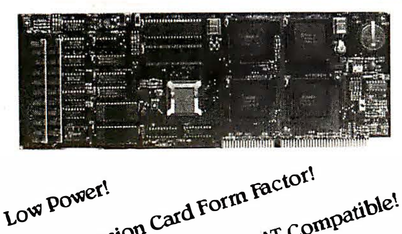
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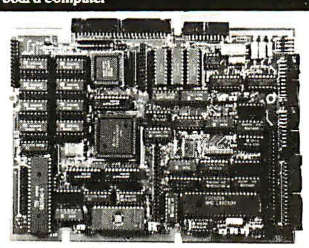
The **OEM-286** is available in both 8 and 10 MHz versions and comes with the Award BIOS

OEM-286 FEATURES

- 100% AT compatible
- 80286 Microprocessor, 8 or 10 Mhz
- 80287 Co-Processor optional
- 64 Kbytes of ROM, can accommodate 128 Kbytes
- 512 Kbytes of RAM
- Keyboard Controller
- Expansion card size factor
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- Battery backed realtime clock
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OEM-286/8	8 MHz AT/CPU	$775.00
OEM-286/10	10 MHz AT/CPU	$825.00
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SB180FX — $409.00
Single Board Computer



SB180FX TECHNICAL SPECIFICATIONS

PROCESSOR
- Hitachi HD64180, an 8-bit CPU in a 68pin PLCC package
- Superset of Z-80 Instruction set including hardware multiply
- Integrated Memory Management Unit with 512K bytes address space
- Dynamic RAM refresh
- Wait state generator
- Clocked serial I/O port
- 2 channel Direct Memory Access Controller
- 2 channel Asynchronous Serial Communication Interface
- 2 channel 16-bit Programmable Reload Timer
- 12 interrupts
- Dual bus interface to 68xx and 80xx support chips
- 6.144MHz, 9.216MHz, and 12.288 MHz system operation

MEMORY
- 512K bytes dynamic RAM on board
- Memory externally expandable to 4 Mbyte RAM
- Either an 8K 2764, 16K 27128, or 32K 27256 EPROM usable
- Full function 8K ROM resident monitor

INPUT/OUTPUT
- Console RS-232 serial port with auto baud rate select to 38,400 baud
- Peripheral RS-232 serial port, full handshaking, 150-38,400 baud
- Line printer parallel I/O port
- 24 bits bi-directional Parallel I/O
- 19-bit address decoding, I/O port decoding, and dual bus interface brought out to expansion bus connector
- Can be directly attached to GT180 640 x 480 color graphics adapter
- Fully implemented SCSI hard disk and communications bus interface

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- Uses Standard Microsystems 9266 disk controller
- Compatible with NEC 765A controller
- On-chip digital data separator
- Can control 3¹/₂", 5¹/₄", and 8" floppy disk drives—up to 4 in any combination
- Handles both FM encoded (single density) and MFM encoded (double density) data
- NCR 53C80 SCSI bus controller for hard disk or network communication

SOFTWARE COMPATIBILITY
- CP/M, ZRDOS, ZCPR3 Compatible

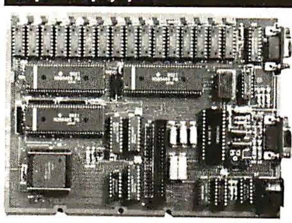
SB180FX-1	SB180FX - 6.144 MHz computer board populated w/ 256K bytes RAM, 8K byte ROM monitor, without SCSI chip. Add $50.00 for 9 MHz.	$409.00
SB180FX-1-30	SB180FX-1 computer board as described above with Z-System software including ZRDOS, ZCPR3, editor, utilities, ZAS assembler, and ZDM debugger. BIOS and ROM monitor sources, and BIOS for SCSI hard disk. Supplied on five 5¹/₄" SB180 format DSDD disks.	$499.00

SB180 — $299.00
Single Board Computer

SB180-1	SB180 - 6.144 MHz single board computer w/256K bytes RAM and ROM monitor. Add $50.00 for 9 MHz	$299.00
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GT180 — $395.00
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The **GT180** has both TTL RGB (red-green-blue intensity) and analog RGB outputs, is totally compatible with virtually all standard and multiscan CRT monitors, and has a connector for an IBM PC keyboard.

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- Hardware drawing commands: LINE, RECTANGLE, POLYLINE, POLYGON, CIRCLE, ELLIPSE, ARC, FILLED RECTANGLE, PAINT, PATTERN, WINDOW, and COPY to name but a few
- Automatic translation of logical X-Y coordinates to physical frame buffer addresses
- Fast drawing speed of 2 million pixels per second
- Provides fully programmable horizontal split screens and window screen
- Fully supported by **GT180** Graphix Toolbox written in Modula-2

GT180-1	Graphic Display Expansion Board (TTL RGB only)	$395.00
GT180-2	Graphic Display Expansion Board (TTL RGB and Analog RGB)	$449.00

SB180
Software and Accessories

SB180-U	Uniform Disk Format Conversion Software	$ 69.95
SB180-2MSG/TKBBS	Z-MSG Bulletin Board Software	$100.00
SB180-MOD2	Turbo Modula 2	$ 69.00
SB180-MOD2G	Turbo Modula 2 w/Graphix Toolbox	$ 89.00
SB180-CASE	Four half height 5¹/₄" drive enclosure w/power supply, mounting brackets and hardware for the SB180 or SB180FX	$197.00
SB180-CABLE	Set of 4 cables including power, term, disk and print	$ 79.00

BCC22 — $249.00
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- Supports scanned and encoded keyboards
- 11 Graphic characters
- 25th line reverse video status display
- 21 escape functions
- 14 control functions
- Directly drives composite video or separated sync monitor
- All functions are firmware controlled. Source code available

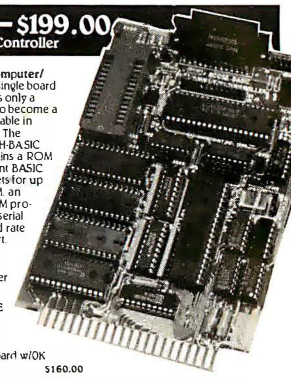
EDITING FEATURES: typeover, clear to screen to space or null, erase to end of page, erase to end of line, absolute cursor addressing.

VIDEO ATTRIBUTES: reverse video, half intensity, double height, double width, underlined, blinking and blank characters.

BUS CONFIGURATION: MICROMINT BCC compatible or no bus connection neccessary for stand-alone operation with parallel keyboard.

BCC22	TERM-MITE Smart Terminal Board	$249.00
BCC22K	PARALLEL Encoded ASCII KEYBOARD plugs directly into TERM-MITE	$ 79.00

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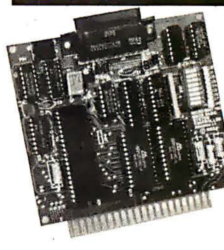
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OEM 100 QUANTITY PRICE
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BCC53
Multi Function Expansion Board w/0K adds 6 ports and 62K bytes **$160.00**

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BCC11 — $139.00
Basic Controller



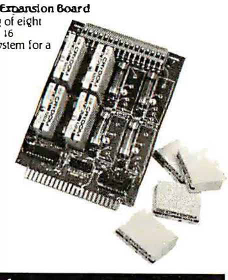
Features:
- Uses Z8 single chip microcomputer
- On board tiny basic interpreter
- 2 on board parallel ports & serial port
- 6 interrupts (4 external)
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BCC11*
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word, such as *say*, *saying*, and *said*, or for terms related in meaning, such as *say*, *talk*, and *speak*. Genealogists might want to examine passages in a historical work for words like *born*, *married*, and *died*. For this operation, you position your cursor at the designated keywords and press Insert; the words you select are then displayed in a list. When the list is complete, you press Return to display the words in their original contexts.

You can use wild cards to enter a word fragment, like **scen**, for retrieving a series of related words, like *ascent*, *ascend*, *ascended*, and *descend*. WordCruncher also lets you generate unique word lists that can be used for making dictionaries, glossaries, or thesauri; cluster all passages ending with question marks; sort words by word frequency; and create charts giving parallel word-frequency listings for different texts.

A Quick Reference

Using WordCruncher is faster, more efficient, and more pleasant than working with printed concordances. If you need a hard copy of any of the data you've viewed, you can easily print out the screen displays, eliminating the tedious note-taking that's necessary when you work with printed concordances.

However, if you want a printed concordance, WordCruncher can create one with the data already present in the indexed files. WordCruncher generates its concordances in the KWIC (keyword in context) format, in which each keyword is followed by a word-frequency listing, the original location of the entry, and a line from the source with the keyword in its center.

A hard disk is virtually a necessity for generating concordances, since even small ones take up a lot of storage space. For example, one of my files, based on 10 printed pages, is 20K bytes in ASCII form and yielded a concordance of over 400K bytes—more than you can store on a double-density 5¼-inch floppy disk.

WordCruncher can handle files up to 3 megabytes long; however, for generating concordances, it's best to work with files that are under half a megabyte because of the size of the work files. For larger files, you can index the text in sections and then concatenate them with the WordCruncher linking routine. Linking is also useful for updating files. It's easier to index a file made up of new entries and link it to an already indexed file than to revise the entire original file and reindex it.

Not for Novices

WordCruncher has advanced routines that may take some time to learn, so it's

continued

WordCruncher version 4.1

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Format
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Language
Pascal

Documentation
273-page manual

Price
$299

Inquiry 904.

not a program for novices. Before buying WordCruncher, you should be familiar with the commonly used MS-DOS commands (you will need them for copying files, installing the program, and other preparatory tasks), be adept at word processing, and know how to translate your word processor's data files into ASCII format.

The manual contains indexed sample files that you can use when learning WordCruncher. Its lessons are arranged so you can experience the most enjoyable part of the program, viewing indexed files, before learning the indexing process. This is a good idea, but some of the lessons are a bit confusing. At times you're given instructions without being told what you're trying to accomplish or why a certain procedure is necessary.

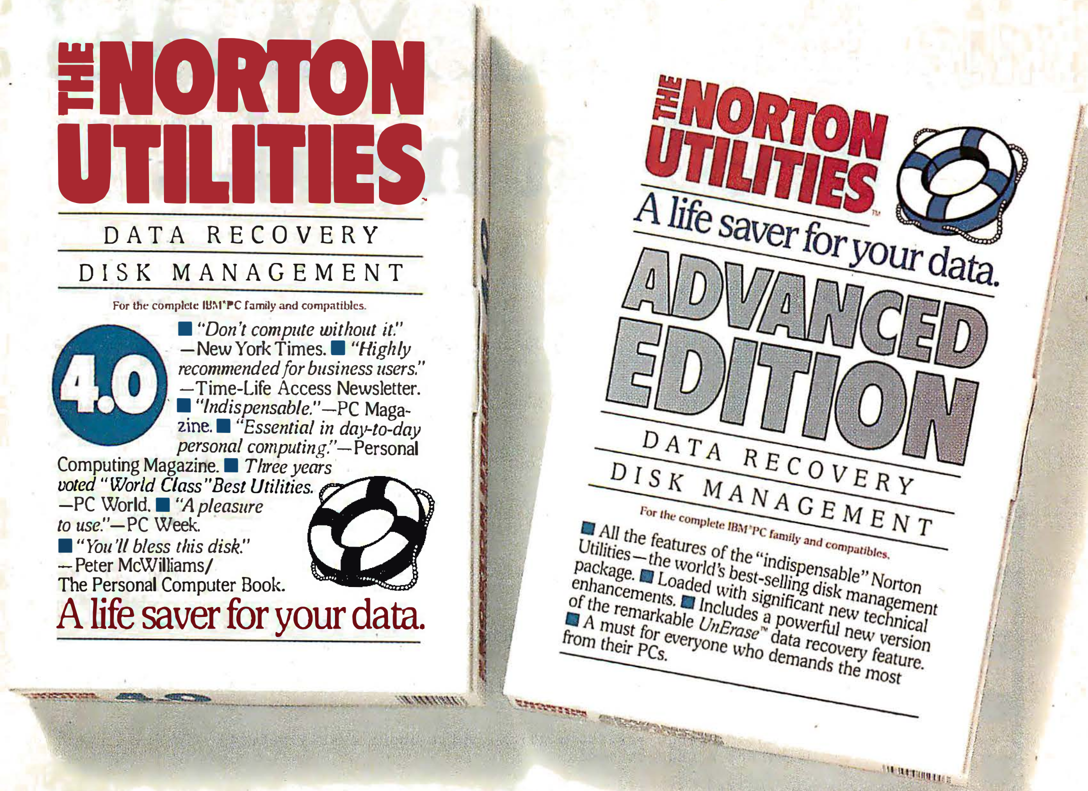
The on-line help information is useful, but some help screens refer to the computer's function keys by WordCruncher's special names instead of by their numbers. A keypad template listing these function-key names isn't supplied. [Editor's note: *Version 4.2 of WordCruncher has been released since this review was written. According to ETC, this version of the program includes keypad templates.*]

Strengths and Weaknesses

ETC could add a couple of routines to improve WordCruncher; for example, an easy way to generate concordances that list only phrases or words repeated with a specified frequency, such as words appearing between two and 10 times. But in general, the program is remarkably well equipped with a variety of sophisticated features.

WordCruncher is not for everyone, but if you need text-retrieval software, this program is outstanding. It provides advanced routines that rival those in mainframe text-retrieval programs, such as those developed at Oxford and Cambridge Universities, the University of Waterloo, and the University of Colorado. It has an intelligent design, particularly in its powerful and convenient ways of arranging and displaying output. WordCruncher takes some time to learn, but once you discover its capabilities, you'll find the time well spent. ■

Rubin Rabinovitz is a professor of English and is the author of a book about the SAMNA word-processing program. He can be reached at the Department of English, Campus Box 226, University of Colorado, Boulder, CO 80309.



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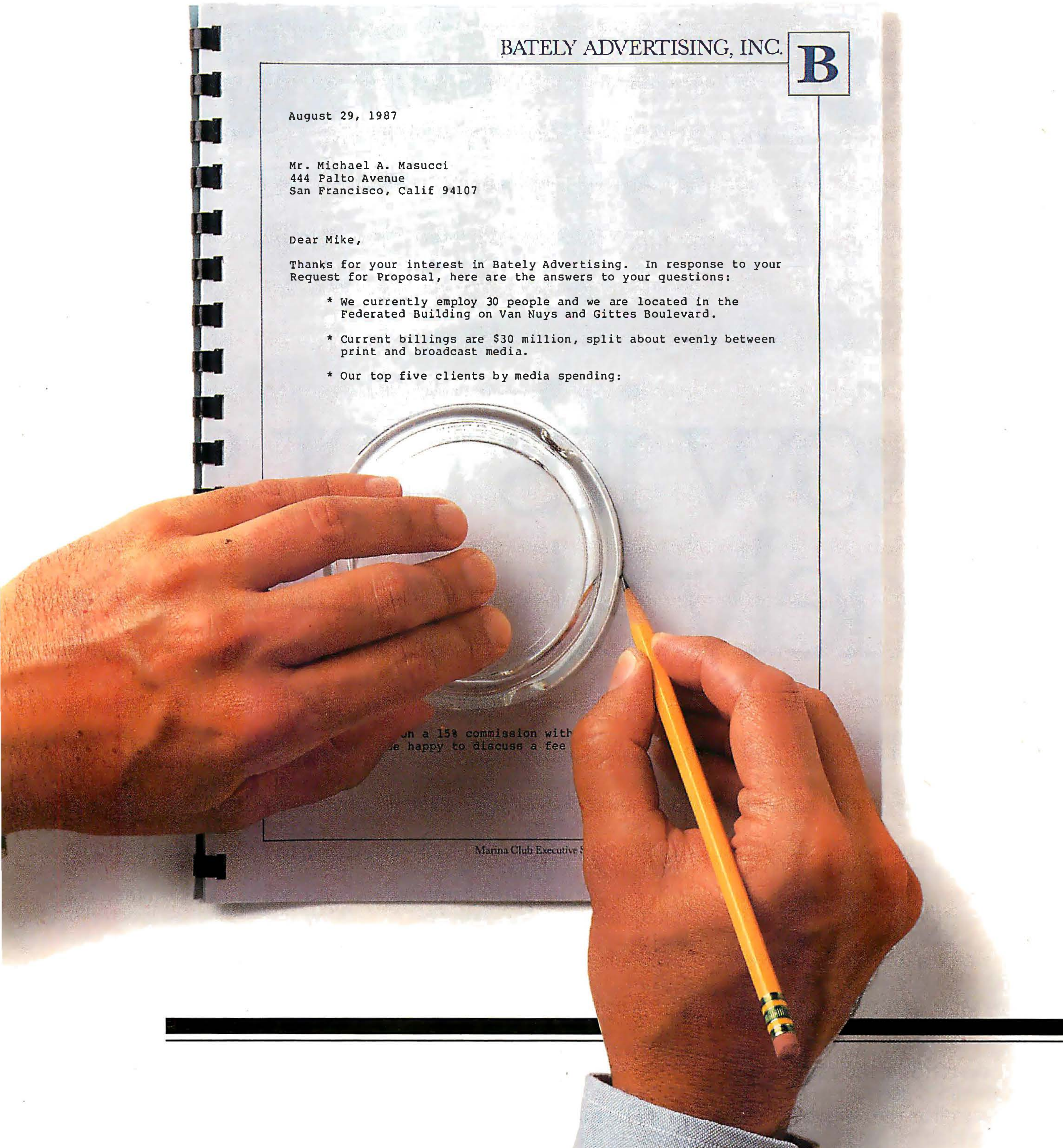
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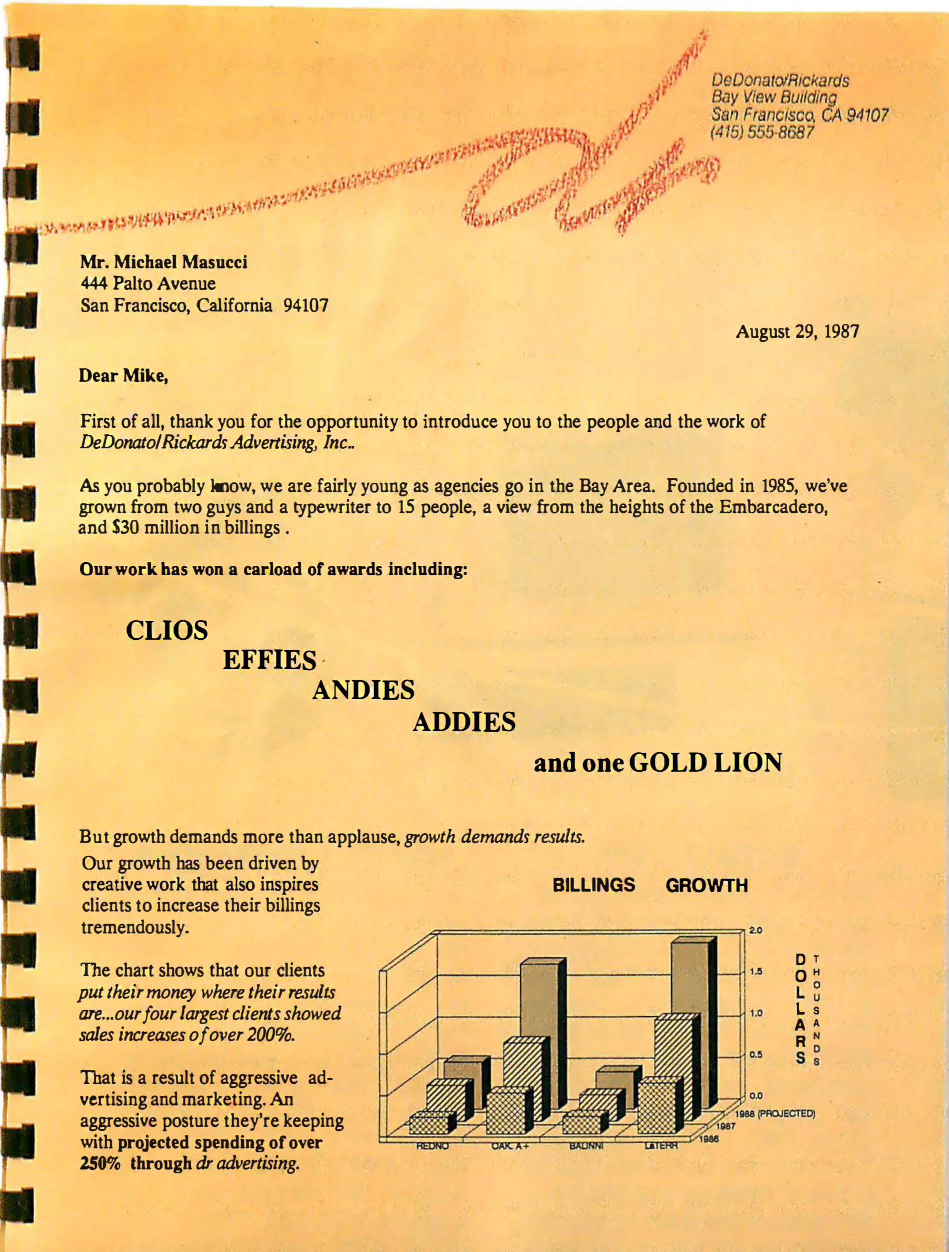
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On the Road to Karlsruhe

Jerry Pournelle

A trip to Germany gives a new hard disk portable its first road test

I'm writing this in the business class of TWA 630 from Los Angeles to Paris with connection to Stuttgart. Roberta and I are both speaking at the Micro Europe Conference in Karlsruhe next week. We've come early to get over jet lag. The notion is that we'll land in Stuttgart and drive to Zurich for the weekend. Zurich is one of my favorite cities, and with any luck I'll have a report on the latest doings at ETH (the Swiss Federal Institute of Technology) before the end of the column.

I'm writing with the Zenith Z-183, a hard disk version of the Z-181 laptop. They took my advice on the Z-183: it has a handle, longer battery life, and a good hard disk. It's just as readable in bad light as the Z-181. Alas, it's heavier, but you can't have everything.

I guarantee you it's rugged: when we got out of the limousine at the airport this morning, the porter dropped the machine from about 4 feet onto the concrete. The case flew open, and a dozen or so keys popped off.

In panic, I grabbed the computer and set it on the hood of a car just behind me to see if it would still run; whereupon a lady burst out and demanded that I cease defiling her Dodge Dart. I had to find another table. There were some anxious moments as I gathered up all the keys from the pavement and popped them back on, but when I fired up the machine, it worked fine.

I think I had remembered to use the SHIP command when I shut it down. That parks the hard disk heads. Whether I did or not, I sure will in future. Meanwhile, I don't recommend that you drop your Z-183, but it doesn't seem to have hurt this one, barring a few scratches on the case.

The Z-183 is a bit large for using in your lap on an airplane, but you can do it if you're in first class or business class. I wouldn't recommend trying it in tourist, at least if you're as large as I am, but then I was never able to do any real writing in tourist with any machine whatever.

Incidentally, TWA business class is an anomaly: the seats are big enough to work in, but all the cabin attendants seem to be assigned to first class or tourist. I've been trying to get a drink for half an hour. It saves you a lot of money over first class, but you might want to bring your own drink.

When we got to Paris, we changed planes, and the boarding passes they made for us back in Los Angeles put us into tourist class, where, of course, there were already people in our seats. TWA moved us up to business class again, but we got tourist-class breakfast since they didn't put enough of the other kind of breakfasts aboard.

One feature of tourist-class breakfast is a tiny container of apple juice optimally designed to spill the stuff all over us and into the computer. It will be interesting to see how the Z-183 survives that. They brought us the *International Herald* with a sticker proclaiming we got it with the compliments of Apple Computer; could the juice container be Apple's revenge?

Traveling

I almost didn't bring the Z-183. Back at Spring COMDEX, Mark Eppley of Traveling Software handed me an alpha-test copy of his version of a Tandy 102 laptop portable. What he's done is to add a 1½-pound inch-thick clip-on called the Booster Pak, which fits on the bottom of the 102 and gives it rechargeable NiCad batteries, a built-in 300/1200-baud modem, and up to 2 megabytes of unsegmented memory—enough to hold a whole novel, and certainly anything I'm likely to write on a trip.

My Booster Pak also has the Ultimate ROM II, which converts the Tandy display from 40 to 60 characters per line. (Actually, it will let you use 80-character lines, but only by horizontal scrolling; and, for my money, anyone who puts up with horizontal scrolling probably has other nasty habits.)

Eppley's version of the 102 isn't a full-feature PC, of course, but it does have a small database, an outline processor, a communications manager, and quite a good little text editor built into the Ultimate ROM II. It would be more than adequate to do this column, and most of what I actually do when I'm on the road; it's rare that I need a large database, or have to do spreadsheets or CAD either in airplanes or hotel rooms.

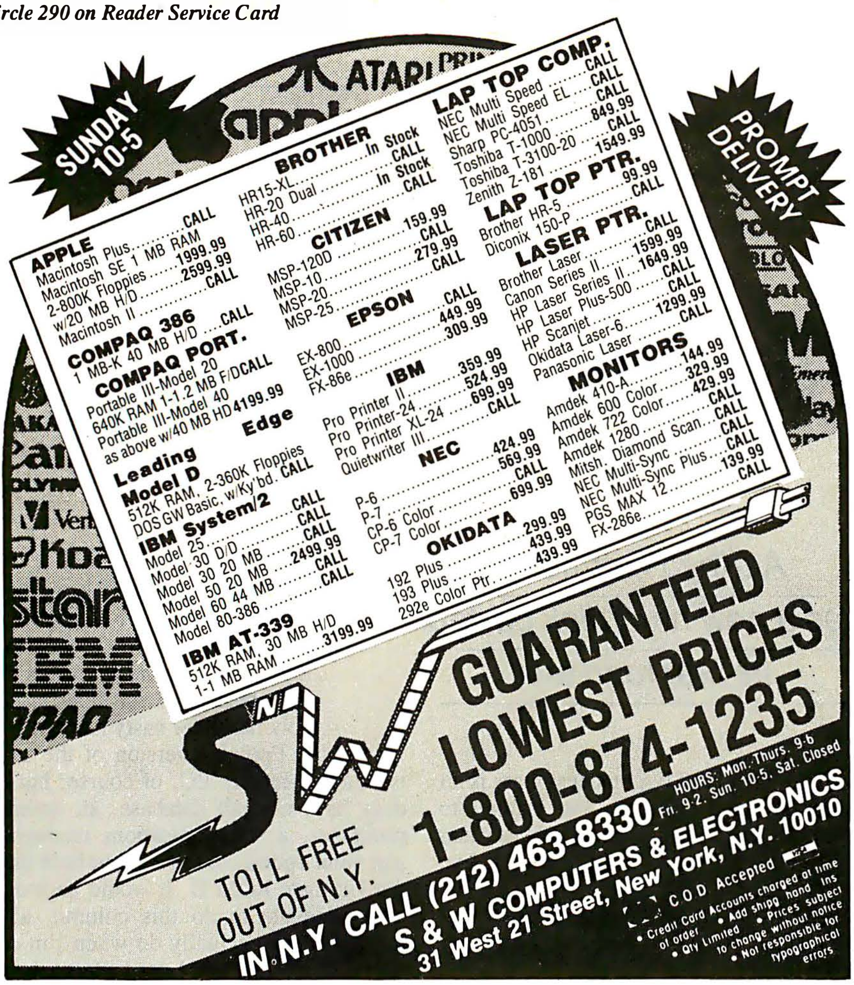
The real attraction of the augmented Tandy 102 is its weight: 4 pounds as opposed to the nearly 14 pounds of the Z-183—and that translates to nearly 18 pounds by the time I add disks, battery charger, screwdriver kit, modem-to-phone cables, and stuff like that. I love this Z-183, but it does get heavy when I trudge from gate to gate at the airport.

On the other hand, I brought two text editors for the Zenith: WordPerfect and Q&A Write. At the moment, I'm using Q&A Write. Once you get used to it, Q&A Write works much the same as the original CP/M-based WRITE, which is to say it can be made more or less invisible. Not entirely, mind you. There are four wasted lines on the screen: a tab-ruler line, a status line that tells me things worth knowing but which I'd rather ask for than have all the time, a blank line, and the twenty-fifth line that has some helpful prompts.

None of that is intolerable, but why the devil can't I turn it all off when I want to? There are times when that information would be valuable, but I'd sure like it better if I could toggle it on and off. Even

continued

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future.





WordStar lets me set help and prompt levels, so it can't be that hard to program.

There are a couple of other problems, too. Q&A Write is intended for use with color systems, and it puts white letters on a blue background. This is fine for color systems, but it makes for lousy contrast on the Z-183. In particular, it's hard to see the cursor unless you adjust the Z-183's contrast and brightness just so. WordPerfect knows how to change colors; why doesn't Q&A Write?

There's no decent word-count mechanism either: to count words, you go to the top of the text and search for " . . ", double dots being the Q&A Write wild card for words. This isn't particularly hard to do, but the search takes a *long* time compared to counting words with WRITE on Ezekial, my CompuPro 4-megahertz Z80 or, for that matter, with counting words in WordPerfect on the Z-183.

Q&A Write's spelling checker is actually faster than the word counter. The spelling checker isn't very smart, by the way. Its dictionary doesn't recognize "IBM," or even "Symantec," and words with apostrophes have to be entered into its dictionary as specials. WordPerfect's word counter and speller are much nicer and much faster—and a great deal easier to use.

Even less forgivable is the way Q&A Write stores your text: it asks you if you want to overwrite your old file, but it doesn't make an automatic backup unless you go through some contortions.

WRITE (and WordPerfect, and darned near every other word-processing program I know) saves your text under a temporary filename, verifies it, and then—and only then—renames your earlier file using the `.BAK` extension, while assigning the current filename to the newly saved file.

To make Q&A Write do that, you go to the command level; ask for `Utilities` (which are *not* the same as the Utilities you get by pressing F8 while in the text mode); ask for `Global Options`; ask for `Set Editorial Options`; and you can toggle between yes and no on automatic backups. There's no mention of this in the index, and if you look in the index under "Options," it mentions only the ones from F8; there's no mention of "Editorial Options" either.

Still, Q&A Write has a nice feel to it. It's easier to learn and easier to use than WordPerfect, and it has much better support for laser printers and fonts.

So Q&A Write will do what I need; provided I am determined enough to spelunk their wretchedly organized manual. I still like the program, but I wish they'd hire a good editor.

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One thing stands out: while the Z-183's weight makes it tough to hump it through airports, once you get it set up, it's sure nice to have 20 or more lines of text on the screen, and both Q&A Write and WordPerfect have other features I'll never have in the editor that comes with the Tandy 102. (Actually, "never" is a big word. Mark Eppley and his Traveling Software geniuses have done wonders with the Model 100 series, and I wouldn't be surprised one day to find they'd actually ported Q&A Write to the machine.)

Another nice thing about the Z-183 is the backlit screen. They've just started the movies and turned off the lights, and I'm still working. With the TRS-80 Model 100 or the NEC PC-8201, I'd have to turn on the reading light, disturbing the other passengers, and I would still have trouble seeing the screen. I can see the Zenith screen fine in the dark.

I've been running the Zenith about 3 hours now, with hard disk saves every couple of paragraphs, and the "Low Power" light hasn't come on; it will be interesting to see how long it will run.

(I never found out: I worked a little more than 4 hours before we got to Paris. The "Low Power" light never did come on. When we got to Zurich, I set up the machine and plugged a 220-to-110 AC power converter into the wall, then plugged the Z-183's battery charger/power supply into that. I set the converter on "low," and after about 2 hours of work, the "Low Power" light and audio chirp came on. When I turned the power-converter's switch to "Hi Power," the light went off, and presumably the Z-183 has been charging ever since. It has run fine for several hours. More if I learn more.)

I've learned one other thing. If you try to read a Q&A Write file into WordPerfect, WP goes out of its mind; I had to reset the machine to recover. Fascinating.

One of Those Days

I'd intended to get most of this written before we left. Not only is there plenty of stuff to review—Chaos Manor is well-stuffed with new equipment and software—but I've been to several interesting meetings I should write about.

Alas, Murphy's Law intervened. My carefully budgeted time was devoured by locusts.

Fast Kat, the Kaypro 386, remains the main machine at Chaos Manor, and I'm in love with the Intecolor Megatrend 19-inch EGA monitor; but we got in something new to test: a new board that accommodates everything from monochrome to PGA, and a 19-inch monitor that not only automatically accommodates all those video formats but comes

continued

with a box that lets it serve as a color TV if I want.

EGA was and is the standard for business and serious word-processing systems, but apparently it will be the shortest-lived standard in microcomputer history. The world is going to 31-kilohertz video with 480 lines, as opposed to the 350 lines of EGA. IBM is building 480-line VGA onto the PS/2 bus, and most major companies, including Zenith, have already announced they will support it. Multisynchronous monitors look like the way to go for a while, and I was anxious to test this one.

Alas, when I got Fast Kat opened up to install the new video board, I found that they'd sent me the wrong cable. Things worked, but not very well. I'm pretty sure it's not the equipment's fault; it isn't supposed to work with kludged-up cabling. I'll have to report on the new video board and monitor next month.

Taking Fast Kat apart is something of a big deal, mostly because of that 19-inch monitor: it's the size of the great blue whale, and this time I had *two* of the monsters to struggle with, the old Intecolor and the new monitor, which is slightly larger than the Intecolor. While I had the Kaypro open, I decided to test Cheetah's suggested remedy to the Intel 386 motherboard problem.

The Intel Design Problem

The problem is easily stated. When Intel designed a motherboard for the 386, they put only 512K bytes of 32-bit memory on it. For various technical reasons, this was easier than designing a full-megabyte motherboard, but it wasn't particularly bright, because it negates a great deal of the utility of the 386.

Kaypro, being in a hurry to get out a 386 and not wanting to design their own motherboard, went with the Intel design. That was probably a mistake; they'd have done better to work with someone like Cheetah to come up with an entirely new board that could accommodate a megabyte. Anyway, Kaypro then added a 2-megabyte fast 32-bit memory board to make up for the Intel defect.

Alas, that leaves a hole between 512K and 640K bytes, which is not easy to fill. There's certainly no easy way to do it with hardware. It can be done with software, namely, Quarterdeck's QEMM 386 memory-management program, which goes in the CONFIG.SYS file (it has to be the *very* first item in CONFIG.SYS) and fools the machine into thinking that 128K bytes of the 2-megabyte added memory is really on the motherboard.

It really is fooling the machine, by the way. If you alter the hardware of the Kaypro 386, you use the Setup program to define the hard disk, set time and date, and tell it how much memory it has, both main and expanded. If you use QEMM to backfill, you must tell the machine it has only 512K bytes of hardware system memory; but after the machine is finished booting and has absorbed QEMM, the Kaypro thinks it has a full 640K bytes of system memory.

There's a price for using QEMM. The program puts the 386 into virtual 8086 mode. This slows things down, although, in general, your 386 will still be faster than a 286 machine. Virtual mode will run software that's full of interrupts, but interrupt processing in virtual mode takes 60 to 80 clock cycles, as opposed to 3 clock cycles when not in virtual mode.

Virtual mode also negates the routines that let other programs directly find added memory. In particular, Ready!, which can use the Lotus/Intel/Microsoft extended-memory convention, works fine but doesn't load any part of itself into

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with Light Tools by Blaise	PC	$168
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Rex - C/86 standalone ROM	MS	$695
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rtree - report generation	PC	$239
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dbQUERY - ad hoc, SQL-based	MS	Call
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high memory on the Kaypro 386. Q&A 2.0 for the 386 can't find the high memory either.

This is no disaster if you're using Quarterdeck's DESQview, which has a memory-swapping system that allows a number of programs to operate at once by moving them into the added memory. Both QEMM and DESQview come with the Kaypro 386 (Kaypro included them on Intel's recommendation), and DESQview does solve a lot of problems. It also creates a few, but, on balance, it's a good way to get past the memory limits of DOS. Most of the time I run the Kaypro 386 under DESQview, and I'm quite pleased with the results.

Still, it would be nice if there were a hardware way to fill in that gap between 512K and 640K bytes, and Cheetah's Gene Sumrall thought he had one. He sent me a partially-populated Cheetah Combo card—a memory-expansion card like the ones I already have in the Zenith Z-248 and the CompuAdd AT clones—addressed to fill that gap.

The Combo card also has a serial port and a parallel port on it. You can address the serial port as COM1 through COM4 or disable either or both ports with DIP switches. Since the Kaypro 386 comes with one serial port and one parallel port built into the motherboard, I decided to disable both Combo card ports for the initial tests. I removed QEMM from CONFIG.SYS, put in the Combo card, and powered up.

The Kaypro BIOS immediately complained that I'd told it I had only 512K bytes of main system memory, but it had found 640K bytes, and would I please run Setup? This seemed like a good sign. I told the machine about the new memory and reset. Everything seemed to run fine. Then I tried to use the DOS `PRINT` spool utility. The machine hung.

Reset. Check all the cables. Do `Control-P`, so that everything that appears on the screen thereafter should also be printed. It is. No problem at all. Do Q&A Write and print a file with it. No problem. Now go to DOS and try to `PRINT` a file again. The machine hung.

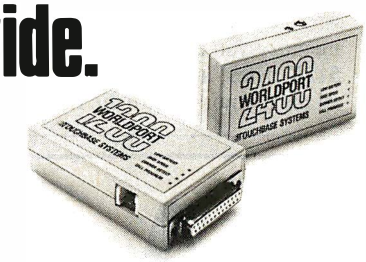
There were other difficulties. Crosstalk was having trouble finding the modem at COM2. I dug out the documents for the OmniTel 1200/2400-baud modem and checked the switch settings. The modem was set up fine. I moved the modem from one slot to another—and lo!, that problem was fixed (I don't know why), but `PRINT` still wouldn't work, and neither would the CompuPro ARCNET PC board.

Not only that, but Ready! still wasn't finding the extra memory. Neither was

continued



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Circle 302 on Reader Service Card

Q&A 2.0. I was messing up the system with the Combo card, and I wasn't getting any good out of it. It was clearly time to remove it and go back to square one using QEMM and DESQview.

I hasten to add that it wasn't the Combo card's fault. I've used Cheetah boards in a number of machines, and they work fine; but they were never intended to solve the Intel motherboard problem. I was getting memory clashes: the least memory you can put on a Combo card is 512K bytes, and it couldn't quite disable all the memory above the first 128K bytes needed to fill between 512K and 640K bytes.

At the moment QEMM and DESQview are good enough, even if virtual mode does slow things down a bit; but one day soon, there will be software written to take direct advantage of the nonvirtual mode of the 386. When that happens, the Kaypro 386 will be obsolete. I've been talking with Kaypro's technical people, and they're thinking of new designs and retrofits.

I'm told the Compaq 386 doesn't have that problem. I should have one about the time I get back from Europe. I'm also told that about the time you read this, Cheetah will have a motherboard with a full megabyte of 32-bit memory. It's even possible that Kaypro and Cheetah will work together.

An interim solution for Kaypro would be a small daughterboard with 128K bytes appropriately addressed. There's also a new AT&T/Olivetti 386 that is said to take advantage of the chip's capabilities: could this be the hit that AT&T needs? While I was at ETH I met the Swiss Olivetti representative, and he certainly thinks so.

Meanwhile, at Micro Europe, Zenith was showing a conversion kit that will let you turn your Z-248 into a 348 in about 20 minutes. They've promised to send me one for use on Zelda. The conversion sets the machine up with 1 megabyte minimum; you can add up to 3 megabytes of fast 32-bit memory as an option. I'm supposed to have one about the time I get home; more next month.

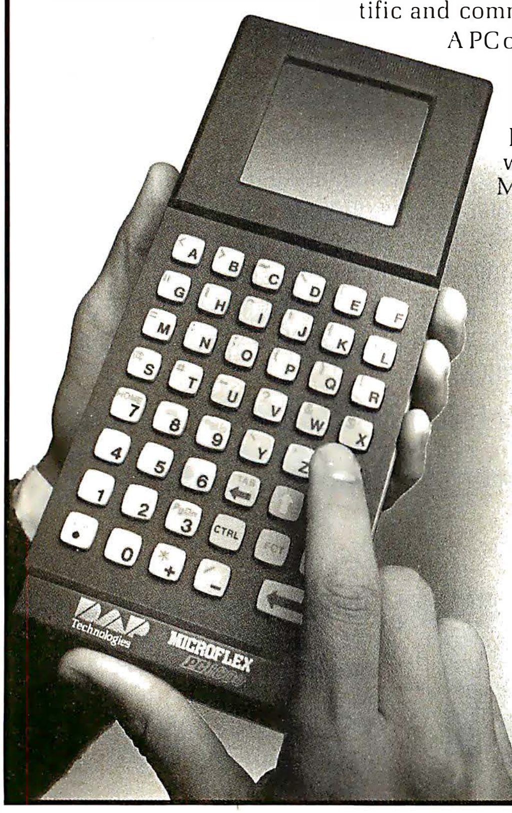
Where To from Here?

My experiences with the Kaypro 386 reminded me of some hard questions raised about the upcoming Microsoft OS/2 during the Borland Languages Conference—about which, more later.

Borland is, of course, a competitor to Microsoft, but only in languages; Philippe Kahn is adamant about not getting into operating systems. "We'd have to work with IBM," Kahn says, "and that's pretty difficult and takes a lot of time. The IBM way is completely different from how we do things. At Borland we have teams of three or four programmers, that's how we get things done, not by putting dozens of people on jobs so that everything gets messed up. We're primarily a language house, and we want to stay that way."

Now that Borland has "merged" with Ansa (Kahn has more than 50 percent of the stock in the combined companies), that attitude may change a bit. It may even be that Philippe was testing the water; but the fact is that we all ought to be asking some hard questions about OS/2 and what's going to happen in the future.

I've looked at this before, so I won't spend a lot of time on it here. Briefly, the issue is this: OS/2 is already about 400K bytes in size and runs most single applications slower than DOS 3.2. If we add at least one 800K-byte program (a major purpose of OS/2 is to break the 640K-byte boundary) and a couple of 300K-byte programs (we're also told we need OS/2 because we need multitasking), we're up to at least 2 megabytes. Multitasking also needs speed, which probably means a 386 chip.



 Circle 82 on Reader Service Card (Dealers: 83)

Programmers aren't fond of EGA color because the EGA chip set doesn't have readable registers: your program can't be sure what mode the screen is in, and thus it's not only possible, but likely, that the software will make some mistakes. IBM has announced that it will not support EGA, meaning that OS/2 probably won't, meaning that you'll need a new video card—and unless you bought a MultiSync or other multiple-format-capable monitor, you'll need to replace the monitor as well.

If we're going to modify the hardware that much in order to run OS/2, why must we bother with an operating system written for the interim 80286 chip? Why not go directly to an operating system written in 386 native code and be done with it? The 286 is doomed, and within a year, there won't be many new systems using it; the 386 will be with us for a long time. Why not have an operating system that uses the 386 as something more than a nonbuggy, faster 286?

The second issue is multitasking. I've always been opposed to multiuser systems. Quite early in the microcomputer revolution, I proclaimed Pournelle's law: One user, at least one CPU. It is now, I think, time to emphasize the "at least one" aspect of that law, because, deep down inside, we don't want to share CPU cycles with anyone, even ourselves.

Most people don't really need multitasking, because most of us don't actually run two jobs at once. We need the ability to get at a bunch of different programs quickly and easily, which is to say we need the ability to keep lots of memory-resident programs on-line. SideKick started as a luxury and ended up as a necessity, and I have no doubt that in the next year or so there will be more programs we just can't do without.

I've already got more desirable memory-resident programs than I can handle: CompuPro's ARCNET network software, Microlytics' wonderful Gofer file finder, Logitech's Logimouse driver, Ready! (for jotting down notes in structured form), and, of course, SideKick itself. There are others that would be enormously convenient to have on-line: units conversion programs, a file comparator, Microlytics' Word Finder thesaurus (which at the moment loads in with Q&A Write, but which would be blooming convenient to have available all the time), and so forth.

Then there are the developments in CD-ROMs. *Grolier's Encyclopedia* is more useful as a demonstration than as a real reference work, but Microsoft's Bookshelf with *Bartlett's Familiar Quotations*, the *U.S. ZIP Code Guide*, *The American Heritage Dictionary*, *The Chicago Manual of Style*, and a partridge in a pear tree would get a lot of use if I could call it up instantly. Micromedex, the medical reference CD-ROM service, is terrific; part of its interface resides in memory.

Even as I write this, a number of companies are putting other references onto CD-ROMs. Things like the *Handbook of Chemistry and Physics*, which I now have to reference by going across the room to the stand that holds that 16-pound monster, and the *Van Nostrand Encyclopedia of Science*. Also becoming available are dictionaries of physics, biology, chemistry, and the like.

Those are all things I use now, and I'm sure it won't be long before I can get CD-ROM reference works I need but at present have never heard of. What I want now is a memory-resident utility that will read whatever CD-ROM I put into the Amdek reader; except that I couldn't use it if I had it, because I don't have enough memory room.

What I *really* want is a coprocessor board that will link my CD-ROM reader to my main system.

I can even identify a needed product: a modem board that has on-board a CPU, memory, and a communications program as good as Crosstalk in ROM. The notion is that the communications system would run in the background without tying up—or even stealing cycles from—the main machine.

The fact is that what everyone wants is not multitasking, with its inevitable slowing of what you're doing in the foreground, but multiprocessing, with more than one CPU on the system bus. Note that CompuPro, with its system master and slave boards, has had that capability all along; the only thing lacking is a truly effective operating system designed around multiprocessing.

OS/2 will come out with great fanfare, and I suppose a lot of copies will be sold. Zenith, among other companies, has announced its readiness to support both PS/2 and OS/2. There will be extreme pressure to make it the new standard of the microcomputer industry. That pressure might even succeed.

If so, the success will be temporary. OS/2 isn't what we need and can't possibly be the wave of the future. The real wave of the future is in multiprocessing. Sooner or later someone will realize that and bring out a 386 native-code operating system that can accommodate multiple processors.

Incidentally, of the major computer languages, Modula-2 is the only one that has multiprocessing built into its very structure.

continued

What Do We Do Now, Coach?

OS/2 is coming out in three phases. First, there will be OS/2 1.0, available before the end of this year; this is a character (not graphics)-oriented 80286 multitasking operating system that's supposed to run most—not all—existing DOS applications. It's very Xenix-like. It comes on seven floppy disks and will cost $325.

After that will come OS/2 1.1, which is OS/2 with the Presentation Manager, which really means OS/2 with Windows. It's said to be 550K bytes now, and since it has to have generic graphics window management, it will probably contain everything but the kitchen sink; I wouldn't be surprised if it ran to nearly a megabyte by the time it's released. No one knows when we'll get it, but the guesses are early to mid-1988. It will be another $325.

Finally, there will be OS/2 Extended, which may or may not use the Presentation Manager from 1.1, and which will cost about $700. It should be available around January 1989. This will have communications and database management incorporated into the operating system. No one knows how large it will be, but I'd be amazed if it could do all that in less than a megabyte. It may be larger than Unix.

The question is, how much of this do we need?

For the moment, none of it: what we have is good enough for the software now available. Microsoft's policies regarding OS/2 software developers are interesting, but I haven't heard that there has been a terrific payoff. Some developers like OS/2 a lot, or say they do, but I know of no significant applications programs that require OS/2 to operate.

Developers will want OS/2 1.0; I don't know anyone else who will need it. The rest of us can wait for OS/2 1.1.

By the time 1.1 comes out, we'll have a better idea of whether we need it or not; there will also be rivals. The main rivals will be DESQview 386 and Microsoft Windows 386.

DESQview 2.0 (for the 286) is already useful. Learning it is something between a hobby and a career, but it gives you great flexibility. Most of DESQview's problems go away once you understand what it's doing; for example, you need to set up most memory-resident programs so that they run in their own windows and *only in the foreground*: if they are told to run in the background, it not only does no good at all, it slows down the foreground task. There are other tricks, but once learned, the system is better with DESQview than without.

Quarterdeck is busily writing a 386 version of DESQview that doesn't force the system into virtual mode.

An even more exciting possibility is Microsoft Windows 386; I haven't seen it, but from what I've heard, it will do just about everything OS/2 1.1 can do, except run programs larger than 640K bytes. At the moment, there aren't any programs that need more than 640K bytes (although some do strange things with overlays to get around the limit). There may be some monsters that big that we can't live without, but let's wait and see. We can already access data areas larger than 640K bytes through extended and expanded memory, and it isn't really very hard to write 386 programs that will do it even better.

In other words, my advice is: "Don't panic." By the time OS/2 is a real alternative, we'll know more about what we may need it for.

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Inquiry 937.

Zenith Z-183 .... $3499
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025

Meanwhile, I am certain there will be a lot of software for the 386 using DOS 3.2, and that won't go away for a long time.

I would be careful about buying stuff that's specific to EGA; if you're buying a new monitor, you'll probably want one that can handle a variety of formats.

Other than that, though, if you need a machine now, get one; it's pointless to wait. We'll have 386 machines with our present DOS for a long time, no matter what happens with OS/2.

Generic and clone 286 ATs will be upgradable with the Cheetah 386 board, if nothing else. Government purchasers can get the Z-248 at a good price, and Zenith has already proposed their 386 upgrade kit to extend their government contract. In my experience, Zenith is a good buy because the company never leaves customers hung out to dry.

At Micro Europe, Zenith announced a new video board that supports everything from monochrome through VGA—including EGA—so even that part of the upgrade won't be a problem; the board will work in non-Zenith machines. I haven't seen it yet, so this is an announcement, not an endorsement.

Beyond OS/2

No one knows what will ultimately win out as the "standard" business computer system. There are more systems in heaven and earth than are dreamed of by IBM. Not only is the Macintosh II making significant inroads, but in Europe other 68000 machines are taken seriously: in Switzerland, the Atari ST is the second-best-selling computer, and this in a country that has nearly as many small computers per capita as the U.S.

Motorola is bringing out the 68030, with on-board memory management, supposedly before the end of this year. I don't at present know of machines designed around it, but you can be sure there will be some.

This looks confusing; but in fact it all helps the user. More competitors mean more choices for us all. Fragmented markets are dangerous only when the fragments are small: when the fragments are large enough, they'll lure software developers into every niche. Moreover, the speed and power of the new chips will help reintegrate the market. Already pc-ditto will run nearly every PC program on an Atari ST. It may not be fast (25 percent to 80 percent of the speed of a 4.77-MHz PC), but it works; with a 68020 in the Atari ST, Lotus 1-2-3 would run on the Atari *faster* than it ran on a PC XT. With Dave Small's Magic Sac, the Atari can also pretend to be a Macintosh.

continued

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In other words, we live in interesting times. What we have out there is a mess—which translates into new opportunities for those who can move fast enough.

Tips

Microcomputer users may find Europe strange. The post offices have a monopoly on all communications: you can't use your modem. If you're going to have to communicate, arrange it in advance, and have a program that uses the RS-232C port. In our case, Peter Dittler, aka "pdittler" on BIX, was kind enough to let Wayne Rash and me use his system. Incidentally, Dittler's company, Conware Computer Consulting of Karlsruhe, Federal Republic of Germany, has some splendid programs to aid desktop publishing in several languages—most notably Chinese.

They also specialize in making German equipment, such as that made by Siemens, talk to U.S. microcomputers. CCC is quite an impressive establishment, and their work in Chinese is nothing short of amazing. If you are working in either of these areas, you need to talk to CCC (Ruppurrer Strasse 4, 7500 Karlsruhe 1, BRD).

We first tried to connect up using Crosstalk. I don't know what happened, but it wasn't successful. Fortunately, Wayne Rash was carrying a copy of HyperACCESS. That has a menu-driven setup that's very easy to use. We were able to BIX with no problems. Then came time to upload my column.

I first tried XMODEM on HyperACCESS. That worked for a while, but after about 10 percent of my file was sent, it would blow up. It did this at least twice, at which point Wayne suggested we use Kermit. You do this by telling BIX you're going to use Kermit for the upload protocol, then telling HyperACCESS to send it that way. Again, it's very simple with HyperACCESS—and it worked the first time, sending about 30K bytes of column with few glitches. From now on, I carry HyperACCESS wherever I travel.

In addition to communications problems, there's electricity. Even if your computer has a 220-volt capability, you'll probably have trouble with cables. My Z-183, and Roberta's NEC PC-8201, both need to have their batteries charged periodically. This is simple enough, provided that you carry a *complete* adapter set, with current converter and a whole set of plug adapters. You need them all, including simple plug extenders: often, the European wall sockets are set deep into a hole, so that the converter can't reach it. You also need a U.S. three-prong to two-prong adapter: the converters don't have a three-hole socket. You may also need gaffer's tape to hold it in.

As to disks and other auxiliary stuff, you can buy them in Germany, but the prices are horrible; bring your own floppies and other supplies. Duct tape isn't available here at all; bring some.

ETH Zentrum

ETH stands for Eidgenossische Technische Hochschule, the Swiss Federal In-

stitute of Technology. Einstein was here before going to Princeton's Institute for Advanced Studies. Think of ETH as a government-supported MIT or Caltech, and you won't be too far off the mark. It has had great influence; for example, MIT's main campus buildings are a near imitation of the central ETH building.

BYTE readers will be most familiar with ETH's Institut fur Informatik. Institutes at ETH are sort of like academic departments, but smaller, and are generally organized around some special area of expertise or competence, or around a particular scholar.

They've consolidated EDP services at ETH under Dr. Walter Seehars, a former IBM physicist, who is responsible for supercomputing, computer science support, university data processing, communications, and coordinating the needs of some two dozen institutes. One of his jobs is to network the entire campus—set of campuses, actually—and that has been done, with some 65 kilometers of coaxial cable and several thousand workstations. They're using a broadband network from Sytek, with Applitek connector boxes. Those are both U.S. companies.

The network integrates everything from simple RS-232C connections to Ethernet, and can also carry video. More than 4000 taps are possible, with 2708 ports in use at this time.

The combined Swiss university system has a budget of more than 200 million francs—about 100 million dollars—to bring in PCs over the next 4 years. They hope to standardize on IBM PC compatibles and Macintosh systems, but now that Sun workstation prices are falling, they've become interested in those. It isn't clear to me that they've thought through the implications of OS/2.

This appears to be a period of consolidation and construction at ETH, but they are at work on a number of applications programs, including a program to integrate text and CAD output. The goal is to come up with a program that technical research people can themselves use to publish their results; at the moment, this generally is done with TEX, and only a few people on the ETH campus understand TEX well enough to use it.

Switzerland is faced with the same problem the U.S. has: how to make best use of supercomputers, and more importantly, how to make the new generation of computer science people familiar with them. The government is about to buy a new machine: either a Siemens or a Cray.

Switzerland has the same problem the U.S. has: how to make best use of supercomputers.

ETH will coordinate the project among all the Swiss.

The ETH computer budget is growing rapidly, more than 25 percent a year. Incidentally, they're in the market for a couple of Unix wizards. The pay is high, Zurich is one of the most pleasant cities in the world to live in, and while it would help to speak German, it's not required. Apply to Dr. Walter Seehars, Direktor Informatikdienste, Rechenzentrum ETH CH-8092 Zurich. It turns out that there are very few Unix gurus in all of Switzerland, so there are probably other opportunities as well.

The Borland Languages Conference

Before we left for Europe, I went to Santa Cruz for the Borland International Languages Conference, an invitational affair

continued

organized on short notice. The major purpose was to promote Borland products, but for me it was a good opportunity to talk to software developers.

The most impressive thing I saw was a preview of Borland's new debugger. They say it will be finished before the end of this year. The Borland debugger has features that go beyond Microsoft's CodeView, with multiple windows simultaneously showing source code, program output, registers, variable values, and nearly anything else you'd like. The first application will be for Turbo C, of course; but they plan to adapt it for their other languages. It's not clear to me just how long that will take.

Borland's demonstrations of Turbo Prolog got me so interested that I'm going to learn that language. Also, there have been a ton of improvements to Turbo Pascal, and some fascinating toolbox programs are now available.

When I first started this column, I wrote a lot more about languages; the Borland conference convinced me it's time to pay new attention to the subject.

Winding Down

I also have Borland's Paradox and Condor 4 from Condor Computer Corp. These are both true relational databases, as opposed to Q&A, which is a file manager.

Often, a file manager is good enough; but when you need a full relational database with a built-in programming language, you need it bad. Among other things, either Condor 4 or Paradox would solve some of the inference problems that I mentioned in my discussion of Q&A in September.

Condor 4 and Paradox seem pretty well-matched in features; they're both very good. The Paradox manual is miles better than the current Condor 3 manual, but Condor promises that the manual for version 4 will be much better. When I get home, I'll compare the two programs: one of those two may be the best relational database available to microcomputer people.

The books of the month are by Robert Jourdain. The first is *Programmer's Problem Solver for the IBM PC, XT, and AT* (1986, Brady Book, $22.95). This is one of the best general books on what's happening in your PC—I'm amazed I haven't noticed it before. There's only one problem: while I was in Europe, someone snaffled the book.

The other is *Turbo Pascal Express* (1987, Brady Book, $39.95), which is a huge volume of excellent Turbo Pascal routines with source code. They're written in assembly language, so they'll run at top speed, and are easily incorporated into your Turbo programs. If you program in Turbo Pascal, you really should have this book.

The book I read on the airplane was my friend Tom Clancy's *Patriot Games*. The only trouble with that book was that I couldn't lay it aside when we got here: I sat up all night in Zurich reading it. Highly recommended if you like adventure novels.

Next month, it's back to the assorted hardware and software that has been piling up. Europe's fun, but there's no place like home, even if home is completely chaotic. ■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply. You can also contact him on BIX as "jerryp."

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on earth



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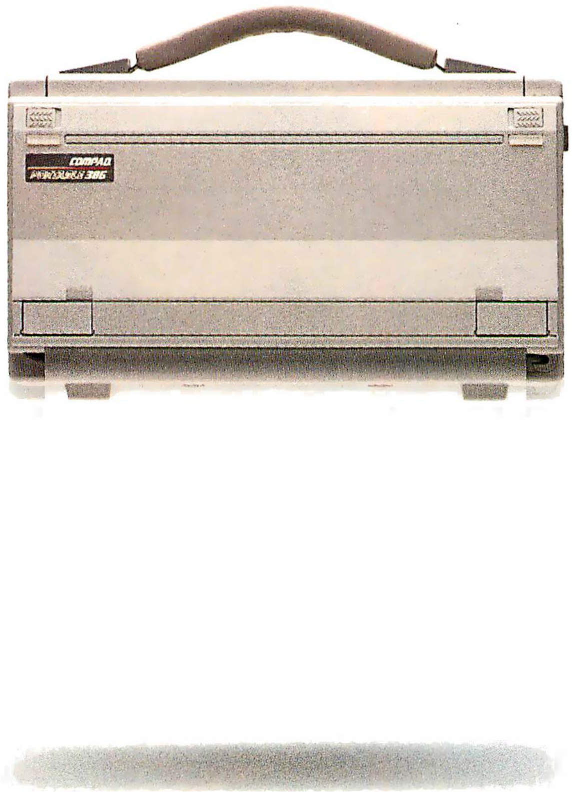
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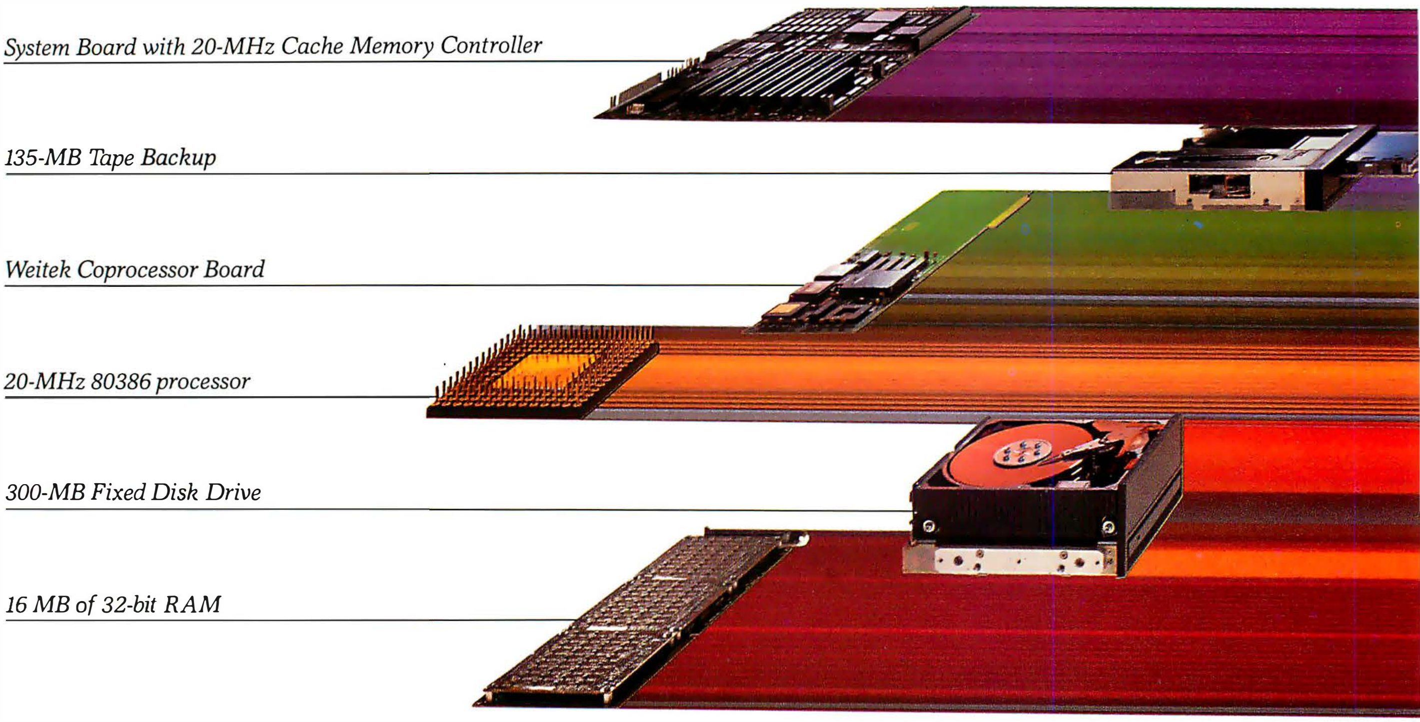
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Compaq also provides 130- and 300-Megabyte Fixed Disk Drives with some of the industry's fastest access times. And when used with disk caching software, they represent the highest-performance storage subsystems available.

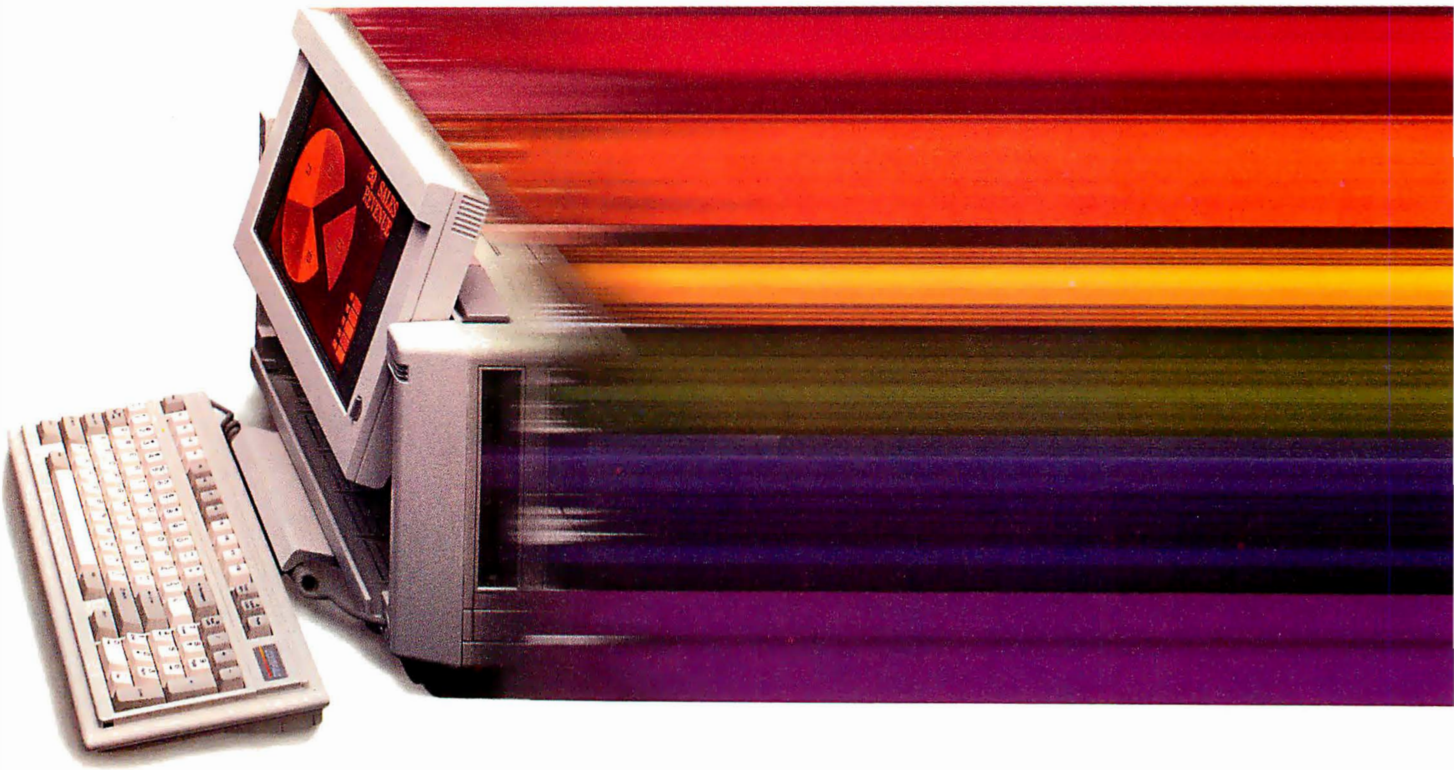
As for memory, Compaq offers 32-bit high-speed RAM. One full megabyte comes standard and is expandable to 16 megabytes without using an expansion slot. Plus, we included the COMPAQ Expanded Memory Manager. It supports the LIM standard so your software can break the 640-Kbyte barrier even before OS/2™ is released.

As tasks become more complex and users demand more advanced capabilities, Compaq responds by raising the standard of performance in personal computing.

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But no one



Pound for pound, it is the world's most powerful computer

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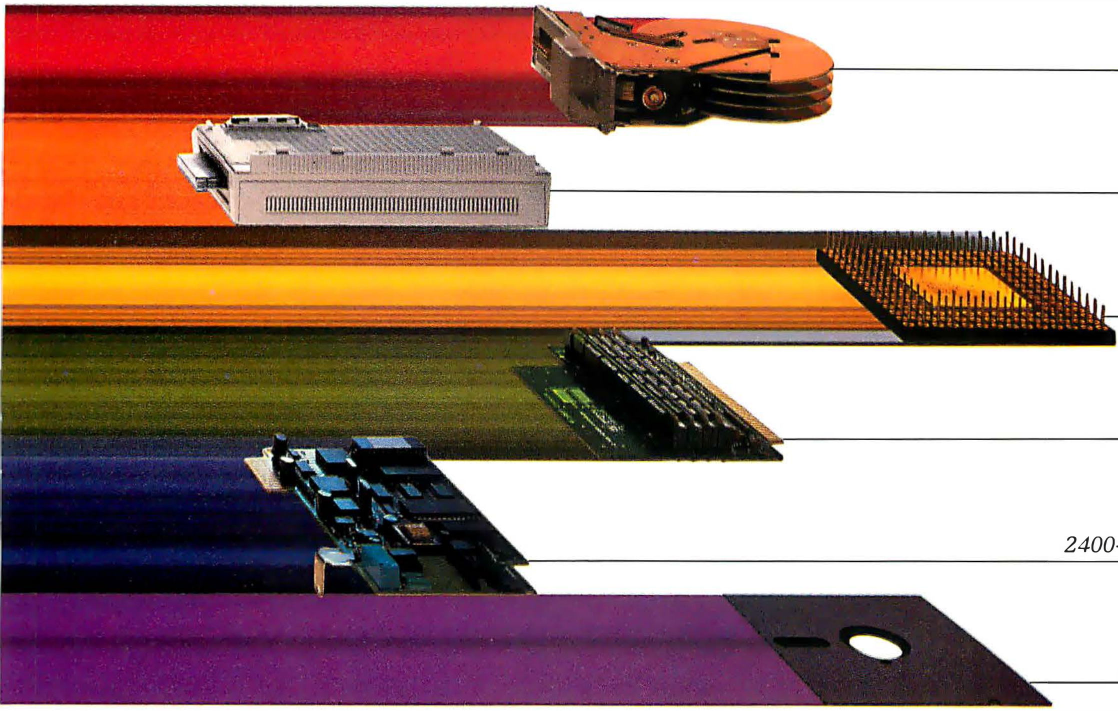
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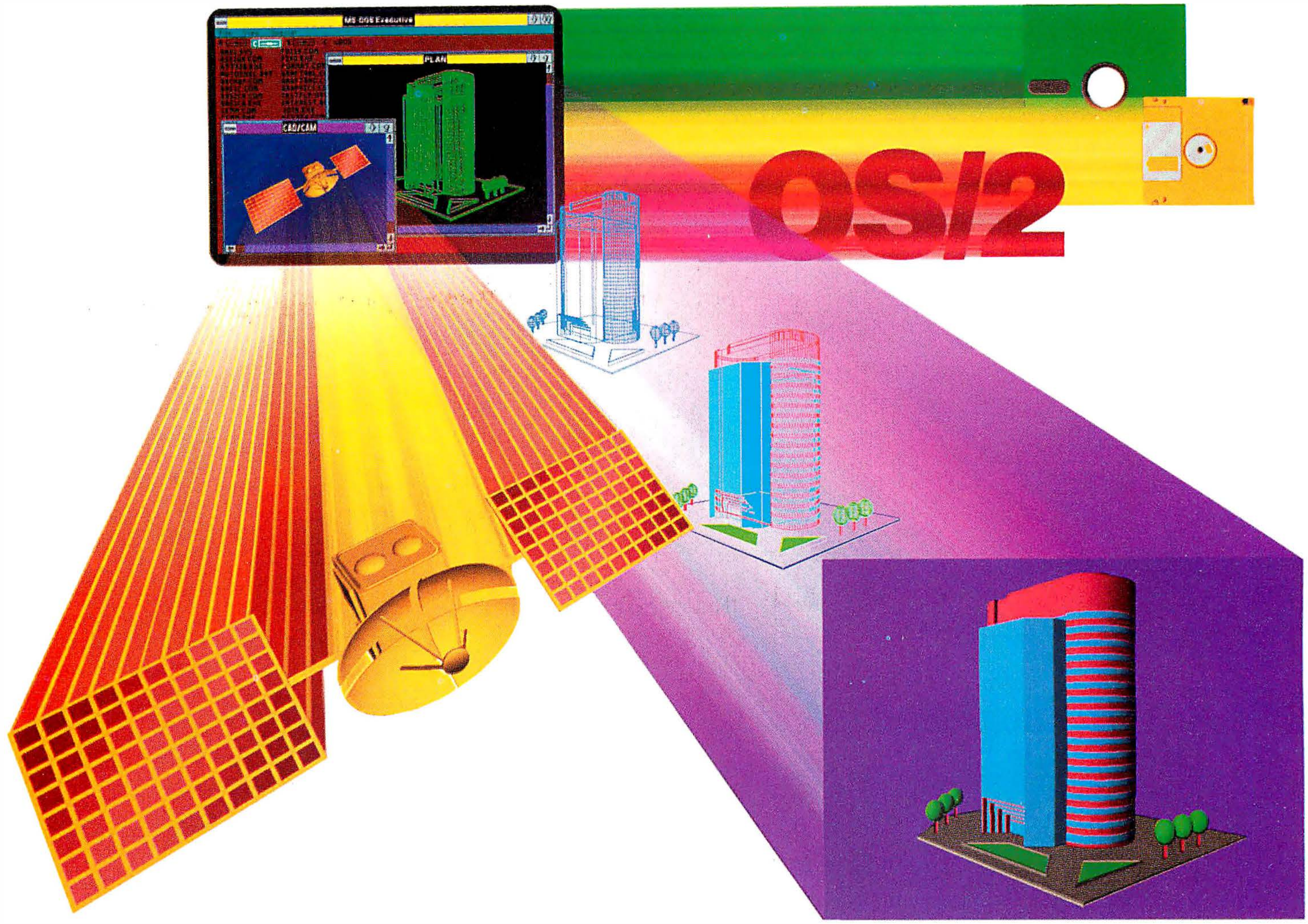
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Split Decisions

Ezra Shapiro

A new WordStar, a portable integrated package, and an editing tool

On the fence. Undecided. Up the creek. If I had more hair, I'd be scratching my head, but I don't want to damage the few remaining follicles. This month's lineup consists of products that are neither clear winners nor unequivocal losers. Some days I feel like praising all of them; at other times, I think about pushing the lot of them off a bridge into a river. Read on; you'll see what I mean.

WordStar, Yet Again

Yes, I know it's late, but it's taken me about six months to get my hands on a copy of WordStar Professional 4.0 (MicroPro, $395). At this point, with MicroPro making noises about version 5.0 "around the end of the year," the question is whether to buy the current release or wait for the new one. Normally, I'd recommend waiting, but this time it's not so simple. It all depends on your relationship with WordStar.

I'll start with the easiest case: If you've never used WordStar, you might as well hold off (unless you've just bought your first computer and are desperate). I'd be willing to bet that version 5.0 will have many new capabilities, among them multiple windows, automatic paragraph reformatting, and drivers for PostScript laser printers, all of which are desirable features lacking in the current product. At that point, WordStar should be able to compete with any of today's state-of-the-art word processors.

I've no doubt that there will be a reduced-price upgrade from 4.0 to 5.0, but you'll have to hassle with the post office. You've lived without it until now, and a few more months won't kill you.

But what if you already own WordStar 3.31? At $89 (plus $5 for shipping and handling), the upgrade to 4.0 looks attractive. However, I have mixed feelings.

WordStar 4.0 is certainly a spiffy successor to earlier incarnations. You've probably seen a list of all the enhancements by now: an undelete command, support for DOS path names, math functions, macros, multiline headers and footers, automatic indexing, simple drawing and access to the full 256-character extended IBM set, a longer list of supported printers, background mail-merge printing, automatic indentation for programs, use of all 40 function keys, and so on.

I'm particularly impressed with the new installation programs; you can change *anything*. MicroPro even throws in a copy of Microlytics' Word Finder pop-up thesaurus, which by itself is almost as expensive as the entire upgrade package.

My reservations have to do with the scope of the improvements. There's a lot to learn—there are so many new commands that they don't all fit into the on-screen menus; you're going to have to sit there with a copy of the quick reference card for a while. If you've got the old WordStar command set engraved in your brain, coping with the new stuff is going to be mildly disquieting. You'll no longer be able to trust your reflexes.

The effect is nowhere near as unsettling as switching to WordStar 2000, but it is a bother. When deciding on whether to get the upgrade, be sure to consider the shock to your nervous system.

You should also think about the issue of trust. I've never been able to really crash old WordStar during years of heavy use. I'm not quite so confident with new WordStar. I tried all the usual tests, even deleting a 200K-byte *column* from a 430K-byte file, and WordStar 4.0 didn't flinch. And it *was* a lot quicker than 3.31. But I couldn't help feeling a little edgy.

So I urge you to balance the wonderful list of new goodies against your need for the ease of coping with an idiosyncratic but loyal old friend. If your only problem with WordStar 3.31 is the embarrassment you feel when you admit to others that you're still using an "ancient" word processor, $94 will buy you a session or two with a good psychotherapist or hypnotist.

Filling a Gap

Next, we have WordPerfect Executive (WordPerfect, $249), an integrated package designed for MS-DOS laptop computers. It includes a small word processor, a calculator, a spreadsheet, an appointment calendar, a to-do list, a telephone directory, and an electronic card file. You run the individual units from a simple shell program. The integration lets you keep as many of the modules as you need resident in RAM for rapid switching, and a clipboard buffer lets you cut and paste between modules.

Everything about this product reflects WordPerfect's usual high standards. The program runs without a hitch, and users of other WordPerfect packages will find the environment comfortingly familiar. Though WordPerfect Executive lacks communications features, you can install any popular telecommunications package to run as a module under the WordPerfect Executive shell. Documentation is brief but thorough, and it's written to be idiot-proof.

As with many integrated products, the components of WordPerfect Executive are weaker than other stand-alone applications. The word processor is effective for short documents, but it can't perform many of the more sophisticated functions of WordPerfect 4.2.

continued

Ezra Shapiro is a consulting editor for BYTE. Contact him at P.O. Box 146069, San Francisco, CA 94114, or on BIX as "ezra." Because of the volume of mail he receives, Ezra, regretfully, cannot respond to each inquiry.

The spreadsheet can import Lotus 1-2-3 worksheets, but kiss your 1-2-3 macros good-bye. You'll also lose a number of 1-2-3's most powerful functions (like @IRR, @DDB, and @STD), as well as some surprisingly basic ones (like @ISERR, @RAND, and @TRIM). The other modules are solid, but don't expect to construct elaborate databases with the card filer.

But as elegantly integrated as this product is, who needs it? The appeal of MS-DOS laptops is the ability to take the same software on the road that you use in your office. Why not prepare a disk with SideKick and Lotus 1-2-3 and include a word-processing add-in like Turner Hall's 4-Word or Blossom's Write-In? Or how about Framework or Symphony if you want integration? Why limit yourself to the simpleminded WordPerfect Executive modules? Beats me.

My theory is that the company is trying to plug the holes in its product line; WordPerfect Executive might be a response to Lotus Metro and the Borland line of pop-ups. Or perhaps some loyal WordPerfect customers have requested an easy integrated package that looks and feels like WordPerfect (the word processor). Whatever the philosophy behind the software, though, I can recommend it only to die-hard WordPerfect fanatics.

As the King of Siam said to Anna, "Is a puzzlement."

Items Discussed

For Comment $195
Broderbund Software Inc.
17 Paul Dr.
San Rafael, CA 94903
(415) 492-3200
Inquiry 939.

4th Dimension $695
Acius Inc.
20300 Stevens Creek Blvd., Suite 495
Cupertino, CA 95014
(408) 252-4444
Inquiry 940.

WordPerfect Executive $249
WordPerfect Corp.
288 West Center St.
Orem, Utah 84057
(801) 227-4000
Inquiry 941.

WordStar Professional 4.0 .... $395
upgrade $89
MicroPro International
33 San Pablo Ave.
San Rafael, CA 94903
(415) 499-1200
Inquiry 942.

A Small Circle of Editors

Editing text on a personal computer has up to now been pretty much a one-person job. It's so easy to modify things. But if you've wanted to add your coworkers into the process, life has been tough—you've had to pass around copies of both your original and the revised version and pray that your readers could spot the changes. For Comment (Broderbund, $195) is an MS-DOS software product intended to facilitate group-editing projects.

For Comment is *not* a word processor. You take your original document and feed it into the program. The software lets readers make comments and suggest

continued

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changes by selecting commands from a short Lotus-like menu. The remarks are then displayed in the lower half of your screen; for comparison, the untouched original remains in the top portion. When everyone is done sniping, For Comment lets you incorporate modifications to the original, then spits out the new version formatted for your word processor. It's as easy as that.

The software license for the product gives you one copy of an "author's" program, which provides the tools for initiating and ending the process; you can distribute 15 copies of a "reader's" program, which lets people comment on your deathless prose.

What's good about this product is that it's currently the only way to perform group editing on a PC without massive headaches. On that basis, I recommend it highly. But as I worked with For Comment, I kept thinking how much easier it would be to make suggestions in blue pencil on a hard copy of the manuscript. Sheesh! I'm supposed to be a champion of new technology, and here I am spurning the wave of the future and looking longingly at pencil and paper.

Recommendations? For Comment works flawlessly, and it's ideal for editing scenarios where you need the control of keeping things in the computer. The software is particularly suited to networked environments. But for raw speed, ease of interface, and intuitive, user-friendly feel, give me the old-fashioned paper approach.

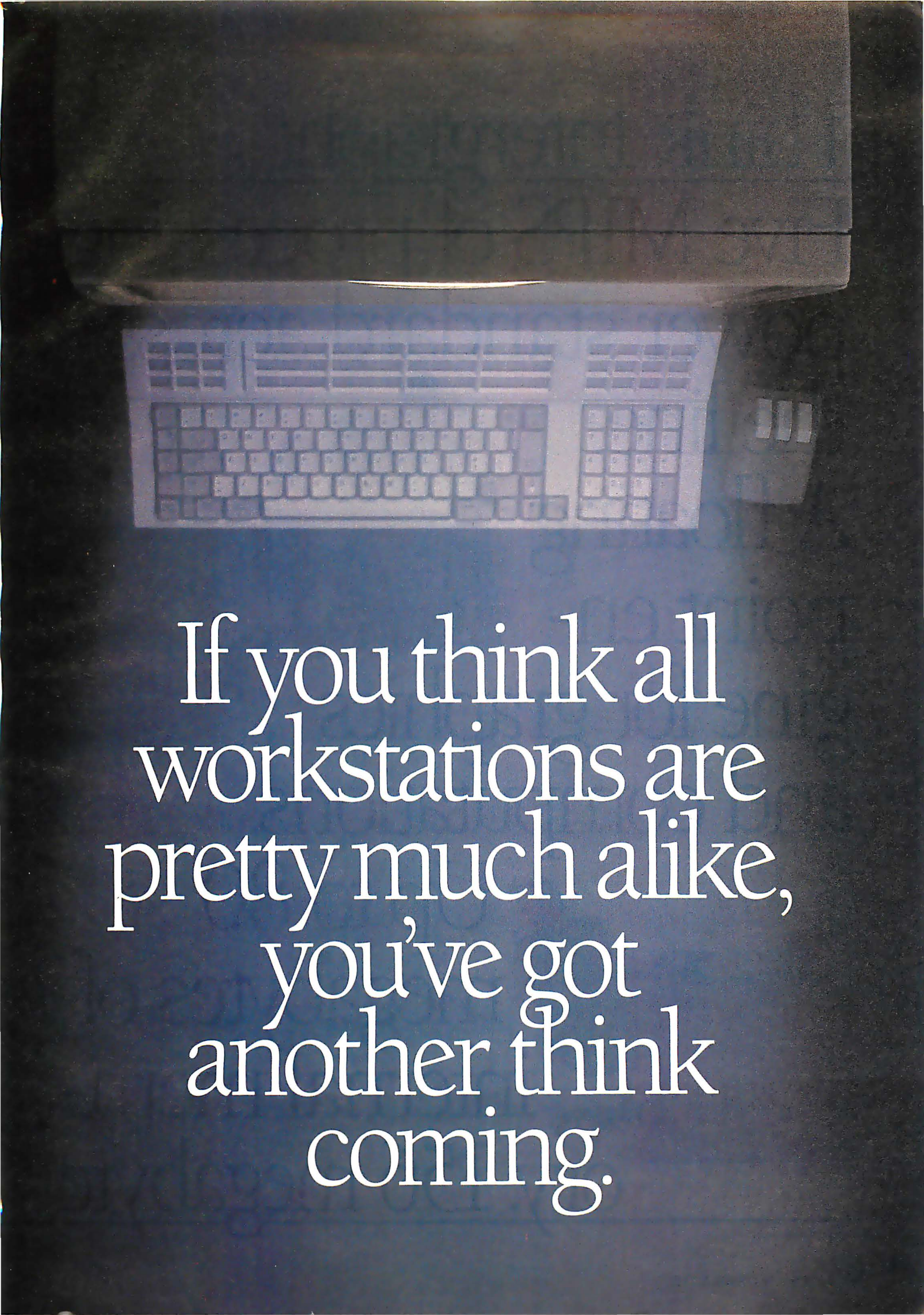
Into the 4th Dimension, Part 2

I'm still struggling with my evaluation of 4th Dimension (Acius, $695), the Macintosh database-development product. I haven't finished my speed testing, but I like the software more and more as I work with it.

I'm slowly getting a better feel for the program. As I improve my skills with it, I'm becoming convinced that 4th Dimension represents a new category of software. It is not a database manager as we currently define the term, nor is it a programming language. It's a true application-development environment. The array of editing and debugging tools makes it an ideal package for the database programmer who wants to cut the time between concept and working application, but the database user who wants an address list should probably look to less high-powered alternatives.

I apologize for promising a final rating of the program in this month's column, but I'd rather take the time to learn and understand a product this specialized and feature-laden. Bear with me as I continue to educate myself. ■

Circle 190 on Reader Service Card

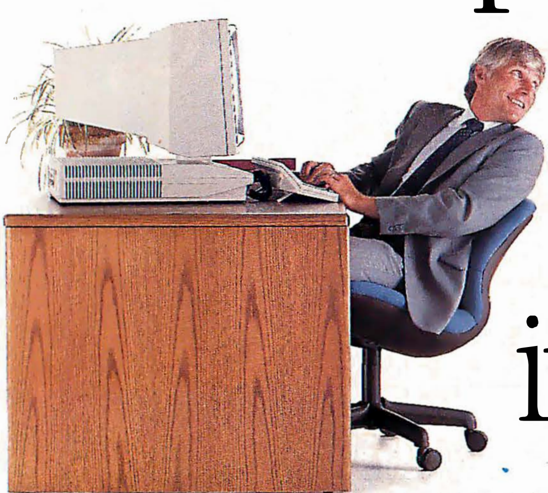

If you think all workstations are pretty much alike, you've got another think coming.

Think Intergraph:

Five MIPS of processing power standard across the line.



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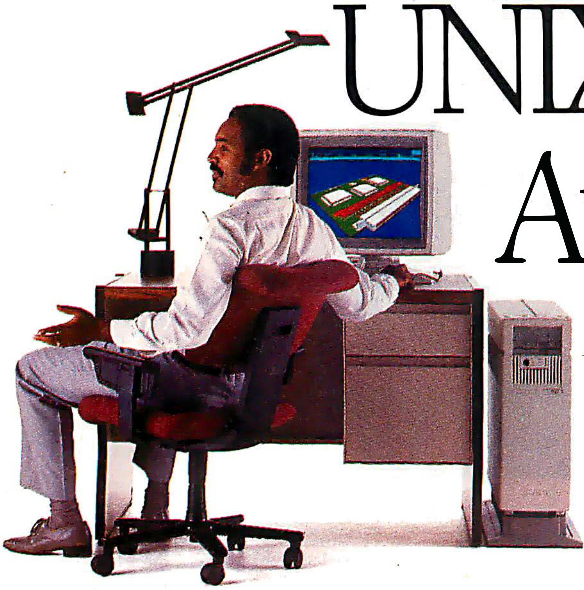
Up to 80 megabytes of internal memory. 156 megabyte



internal disk.
Ethernet with
TCP/IP and
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and RFS.



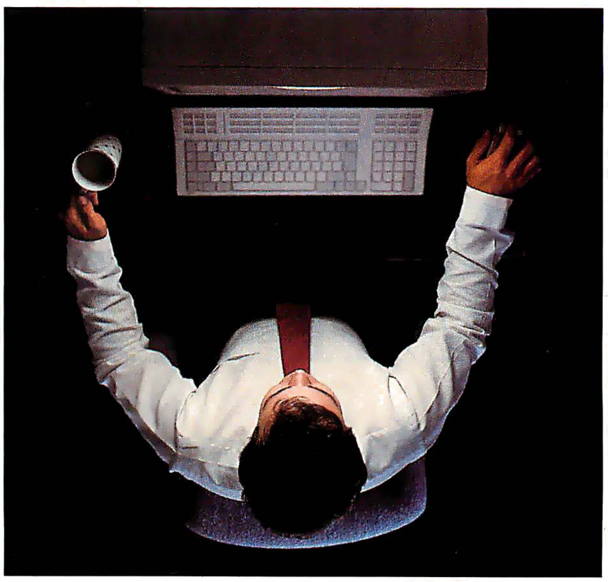
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An I/O pro-
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	GRAPHICS WORKSTATIONS				SERVERS	
	InterPro 32C InterAct 32C InterView 32C InterPro 220 InterAct 220 InterView 220	InterPro 240	InterPro 340 InterAct 340 InterView 340	InterPro 360 InterAct 360 InterView 360	InterServe 200	InterServe 300
CPU	Five MIPS CPU					
RAM	8 – 16 MB*		16 – 80MB		16MB	16 – 80 MB
Graphics Image	GS 32 colors/4096 25,000 vectors/sec	GX 512 colors/16 million 100,000 vectors/sec Double Buffered		GZ 512 colors/16 million 100,000 vectors/sec Double Buffered	N/A	
Processor	80186 1/2 MB memory Asynchronous SCSI 1.2 MB/sec		80386 2 MB memory Synchronous SCSI 4 MB/sec		80186 1/2 MB memory Asynchronous SCSI 1.2 MB/sec	80386 2 MB memory Synchronous SCSI 4 MB/sec
Disk	*156 (up to 7 x 156)					
Floating-Point Engine	N/A			Pipelined, double-precision FPE, 8 MB memory, 1 MB writable control store, 22 double-precision megaflops processor	N/A	Optional
VME Card	N/A		Optional Card Adapter			
Operating System	UNIX System V.3					
Networking	IEEE 802.3 (Ethernet) with XNS, TCP/IP					
Network File Access	NFS, RFS (Optional)					
Windowing	Environ V (Standard) and X Windows (Optional)				N/A	

*32C models come with standard 6 MB memory and an 80MB internal disk drive.

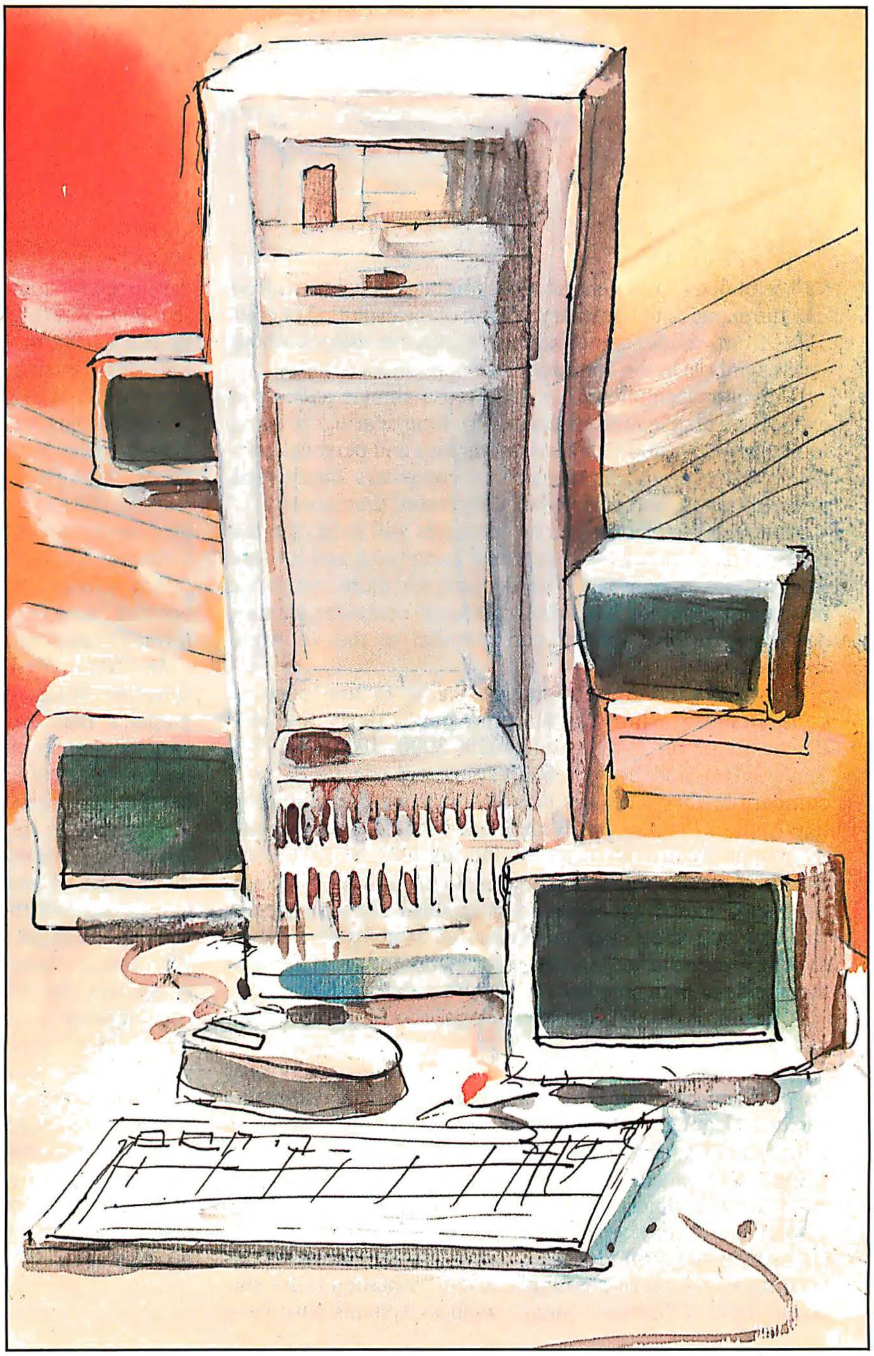


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Workstation Technology



Introduction

Workstation Technology

Technology, as a general rule, migrates downward, from the exotic to the ordinary. Think of the evolution of color TVs, from crude, prohibitively expensive neighborhood status symbols to the commonplace appliances of today.

Computer technology has followed a similar path, from exotic university-built machines to time-sharing systems, minicomputers, and today's workstations and personal computers. At every step, the size of computers diminished, prices dropped, and performance increased dramatically.

Although distinct classes of machines still exist, the distinction between high-end personal computers and low-end workstations is blurring. The demand for more computing power and graphics has driven personal computer technology along a development path parallel to that of workstations.

Workstation manufacturers are trying to lure personal computer users into their arena, particularly the IBM PC-based group. Apollo's Domain 3000, IBM's RT PC, Sun's 3/160, and Xerox's 6085 system all contain PC AT-compatible interfaces. Personal computer manufacturers like Apple, Compaq, TeleVideo, and even IBM are bringing systems to the market based on the same 32-bit CPU chips used in some low-end workstations. In this In Depth section, we'll shed some light on these distinctions and show the advantages and shortcomings of various systems. We'll also look at some advances in computer technology that apply to the worlds of both personal computers and workstations.

A Resource Guide included in this section contains a sampling of workstation manufacturers and their products.

In "A World Of Workstations," Phillip Robinson looks at the cost and capability overlap between personal computers and workstations, and the areas where high-end personal computers are still lagging behind workstations. You'll get a glimpse of planned developments designed to maintain the workstation's rapidly eroding "capability edge."

Multiple display windows are necessary to keep track of the many concurrent processes running in a multitasking environment. As another example of the "imitation is the sincerest form of flattery" idiom, window systems have been developed for some of the high-end personal computers. Our second In Depth article, "Comparison of Window Systems" by Hal L. Stern, examines the architecture and features of four such systems: the Macintosh Toolbox, Microsoft Windows, the X Window System, and NeWS.

Engineering technologies such as fluid dynamics, finite-element analysis, and aerospace simulation demand high-speed, high-resolution graphics capability from a workstation. Early workstation designs often incorporated proprietary graphics engines and custom-tailored graphics software. This created a problem with data interchange when different makes of workstations were connected on the same network. As a result of this inconvenience, committees were formed to standardize the workstation's graphics interface.

In "PHIGS: Programmers Hierarchical Interactive Graphics Standard," Martin Plaehn describes a proposed graphics interface standard based on hierarchically constructed graphics images. This standard is a giant step in the process of creating a universal graphics interface that will benefit all workstation and personal computer users.

And finally, in "Distributed Processing: The State of the Art," W. Anthony Mason describes the latest innovation in the domain of workstations: distributing the operating system throughout the network to offload much of the multitasking overhead from an individual server workstation. This article examines two recent experiments in distributed processing: the MACH operating system developed at Carnegie-Mellon University, based on a redesigned Unix kernel, and the V operating system used at Stanford University, which uses a "bus and slot" analogy.

In the very near future, the new reduced instruction set computer (RISC)-based CPUs, math processors, and graphics processors now on the drawing boards, or being fabricated, are certain to cause a quantum jump in the state of the art of workstations and personal computers. And we are certain that, even as we go to press, other new developments are taking place in the workstation arena.

—Charles D. Weston and Eva White,
Technical Editors

A World of Workstations

As microcomputers climb the performance curve, workstations slide down the price curve

Phillip Robinson

IN 1980, TECHNICAL professionals—engineers, scientists, architects, and designers—stared glumly at two facts: the low power of microcomputers and the high prices of minicomputers. Microcomputers didn't have the necessary CPU power, memory, shared resources, or display resolution to handle engineering tasks. Minicomputers offered those characteristics, but they were expensive and didn't provide the interactive nature and independence of a personal system.

In 1981 and 1982, Apollo Computer and Sun Microsystems filled that gap with general-purpose workstations, the Domain DN 100 and the Sun-1. Targetted for engineers, these systems had high-speed CPUs, large amounts of RAM, high-resolution displays, large disk memories, and networking to interconnect different engineering stations and shared resources such as plotters, printers, and file servers.

Between 1983 and 1986, Apollo and Sun grew rapidly. In most cases, they sold their systems to OEMs who combined them with additional software and hardware to make specialized engineering systems for particular markets, such as electronic engineering, aerospace design, mechanical CAD, artificial intelligence, computer-aided software engineering, technical publishing, imaging, three-dimensional solids modeling, and even financial services. Since 1981, many other companies have entered the workstation market. Table 1 shows a sampling of the general-purpose workstations available today.

The Workstation Standard

Low-end workstations are surprisingly similar, even though they come from a variety of companies rooted in different parts of the computing business. A baseline workstation today typically has a 32-bit CPU, 4 to 8 megabytes of RAM, 40 to 80 megabytes of hard disk space, a megapixel display, a 10-megabaud networking connection, and a demand-page, multitasking virtual memory operating system. Most workstations are hooked into a network and can access a file server.

Almost all recent workstations have been built around the Motorola 68000 family of microprocessors. This includes the Apollo, Sun, and older Hewlett-Packard designs. There are some exceptions. Digital Equipment Corp.'s VAXstation and IBM's RT PC are built around proprietary chips, and a few 80386-based machines have appeared on the market.

As companies try to squeeze more and more cycles per second out of the CPU, they have followed three tacks. They can simply employ a microprocessor with a faster clock. A 16-megahertz 68020 system gives way to a 25-MHz 68020 system. Or, companies can use the next more powerful member of a chip family. For example, the IBM PC AT (which didn't truly qualify as a workstation but was pressed into that type of service by some engineers) was superseded by the 80386-based Model 80, which may grow to full workstation status.

Finally, workstation CPU designers move to proprietary chips. These are often based on RISC (reduced instruction set computer) principles. Typical of this change is Sun's move to a RISC-based architecture in its recently announced Sun-4 series. IBM's RT PC has the RISC ROMP microprocessor, while the new HP 9000 Series 800 has Hewlett-Packard's Precision Architecture RISC chips, developed in HP's Spectrum project. Even DEC, whose VAXstation has been based on the MicroVAX chip—a chip implementation of the minicomputer VAX architecture—admits that it is looking at RISC, among other new technologies, to create a new workstation processor.

This movement may be in part a response to the impending battle with personal computers: Workstation makers need some edge, and they won't get it using the same CPUs that feed the mass production of IBM, Compaq, and Apple.

While personal computers often measure CPU performance by the speed of the system clock, workstations deal in million instructions per second. The early systems offered about 1 MIPS, and that was soon doubled. The latest low-end workstations, such as the Apollo Domain Series 4000, claim approximately 4-MIPS performance, and that level will probably double in the next generation of low-end machines. The new Sun-4, which at nearly $40,000 (in minimum configuration) is not a low-end machine, claims 10-MIPS speed.

continued

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Table 1: *A sampling of low-end workstation offerings. Most companies offer a variety of options for hard disks, network interfaces, display sizes, and, in some cases, high-performance graphics. A family of workstations will share the same networking hardware and software, and operating system. Networking hardware for the IBM Model 80 or Compaq Deskpro 386 is not directly available from these vendors, but many third-party vendors supply these options.*

Company	Model	Price	CPU	FPU	MIPS	RAM (Mb)	RAM expandable
Apple Computer	Macintosh II	$4796	16-MHz 68020	16-MHz 68881	2	2	8
		$12,184	16-MHz	16-MHz	2	8	8
Compaq	Compaq Deskpro 386						
	Model 40	$7245	16-MHz 80386	16-MHz 80387	N/A	1	10 *
	Model 70	$9893	16-MHz 80386	16-MHz 80387	N/A	2	10 *
	Model 130	$12,545	16-MHz 80386	16-MHz 80387	N/A	2	10 *
IBM	IBM PS/2 Model 80						
	80-041	$7245	16-MHz 80386	16-MHz 80387	N/A	1	16
	80-071	$9180	16-MHz 80386	16-MHz 80387	N/A	2	16
	80-111	$12,545	20-MHz 80386	20-MHz 80387	N/A	2	16
	IBM RT PC						
	6160 Model 10	$7900	ROMP RISC chip	10-MHz NS32081	4.5	1	4
	6150 Model 20	$11,900	ROMP RISC chip	10-MHz NS32081	4.5	1	4
	6150 Model 25	$14,050	ROMP RISC chip	10-MHz NS32081	4.5	2	4
TeleVideo Systems	TeleSTAR/386						
	15DL	$3995	16-MHz 80386	10-MHz 80287	2.2	4	16
	17C	$10,995	16-MHz 80386	10-MHz 80387	2.2	4	16
	19M	$9995	16-MHz 80386	10-MHz 80387	2.2	4	16
	19C	$12,995	16-MHz 80386	10-MHz 80387	2.2	4	16
Sun Microsystems	Sun-3/50	$4995	15-MHz 68020	16.67-MHz 68881 (opt.)	1.5	4	N/A
	Sun-3/60	$12,900	20-MHz 68020	20-MHz 68881	3	4	24
	Sun-3/160	$39,500	25-MHz 68020	20-MHz 68881	4	8	16
	Sun-4/260	$85,500	16.67-MHz proprietary RISC chip	Weitek 1164/1165	10	32	128
Apollo Computer	DN 3000	$4490	12-MHz 68020	12-MHz 68881	1.3	4	8
		$12,400	12-MHz 68020	12-MHz 68881	1.3	4	8
	DN 4000	$13,900	25-MHz 68020	25-MHz 68881	4	4	32
		$18,900	25-MHz 68020	25-MHz 68881	4	4	32
Hewlett-Packard	9000-318	$7800	16.6-MHz 68020	16.6-MHz 68881	2	4	N/A
	9000-330	$22,100	16.6-MHz 68020	16.6-MHz 68881	2	4	8
	9000-350	$32,900	25-MHz 68020	20-MHz 68881	3.77	8	32
	9000-8255	$42,500	HP Precision Architecture RISC chip	Proprietary	8	8	56
Digital Equipment	VAXstation 2000	$4600	20-MHz VAXstation II processor	Proprietary	0.9	4	6
		$12,525			0.9	4	6
Masscomp	MC 5350	$16,250	16-MHz 68020	16.6-MHz 68881	2	2	4
	MC 5450	$22,250	20-MHz 68020	I20-MHz 68881	2.5	2	10
Xerox	Xerox 228S	$17,290	16-MHz 68020	68881	2.5	4	16
		$22,090	16-MHz 68020	68881	2.5	4	16
NEC Information Systems	NEC 1500	$27,500	16.6-MHz 68020	16.6-MHz 68881	2	4	32

* RAM expandable to 10 megabytes on the motherboard.
** Under MS-DOS or PC-DOS 2.0 or higher.
*** The Presentation Manager will be included with OS/2 version 1.1; availability to be announced the fourth quarter of 1987.

Hard disk	Screen size	Resolution	Networking Hardware	Networking Software	Operating System	Window environment	AT-compatible card option
(800K floppy) 80	12″ mono 13″ color	640×480 640×480	AppleTalk	AppleTalk	Mac A/UX (Unix)	Mac	Yes
40 70 80	12″ mono 13″ EGA color 13″ EGA color	640×200 720×350 640×350 720×350 640×350 720×350	N/A	N/A	MS-DOS, Xenix	MS-Windows **	Not necessary
44 70 115	12″ mono 12″ color 16″ color	640×480 720×400 1024×768	N/A	N/A	PC-DOS 3.3, OS/2	MS-Windows,** Presentation Manager***	Not necessary
40 40 70	12″ mono 12″ color 15″ mono	720×512 720×512 1024×768	Token-Ring	IBM	AIX (Unix)	X Window	Yes
Diskless 40 71 71	15″ mono 17″ color 19″ mono 19″ color	1280×1024 1280×1024 1280×1024 1280×1024	Ethernet	TCP/IP, RFS,NCS	Microport's DOS Merge-386 (Unix & DOS)	X Window	Yes
Diskless 71 141 560	19″ mono 16″ color 19″ color 19″ color	1152×900 1152×900 1152×900 1152×900	Ethernet	NFS,RFS, TCP/IP	Sun OS (Unix)	NeWS, X Window	Yes
Diskless 80 Diskless 80	15″ mono 15″ color 19″ mono 15″ color	1024×800 1024×800 1280×1024 1280×1024	Ethernet	NCS,RFS, TCP/IP	Aegis, Domain/IX (Unix)	X Window, NeWS	Yes
Diskless 80 131 131	17″ mono 16″ color 19″ color 19″ color	1024×768 512×400 1280×1024 1280×1024	Ethernet	RFS	HP-UX (Unix)	X Window	Yes
Diskless 159	15″ mono 15″ color	1024×864 1024×864	Ethernet	DECnet, VAXcluster, NFS	Ultrix (Unix), VMS	X Window	Yes
71 71	12″ color 19″ mono	640×480 1152×910	Ethernet	TCP/IP, X.25	RTU (Unix)	MC-Windows	No
86 86	19″ mono 19″ color	1024×792 1024×792	Ethernet	TCP/IP, XNS	Berkeley Unix 4.3	Proprietary	No
86	20″ color	1280×1024	Ethernet	TCP/IP, NFS	Unix System V	NEC Window Manager	Yes

One factor that has long distinguished workstations from microcomputers is their high-speed floating-point (FP) processing. Most have some special hardware for increasing FP mathematics—calculations that are frequently performed in graphics manipulations and in scientific equation solving. The less expensive machines depend on FPP (floating-point processor) chips—coprocessors that work with the main CPU. The more expensive machines sometimes offer FPP add-on boards and even special-purpose vector accelerator processor boards.

Workstations built around the 68020 most often use the Motorola 68881 FPU (floating-point unit) chip as the FP coprocessor. Systems built around the 80386 use the Intel 80287, the Intel 80387 (since it became available in mid-1987) and even the high-power Weitek FP chips. The TeleVideo system, for example, offers a choice of the 80387 or the Weitek chips. As workstation performance improves, there will undoubtedly be a push in FPPs similar to that in CPUs, with proprietary designs replacing some commercial FP chip components.

Many engineering programs are large and make considerable use of interactive graphics. Engineers often depend on multitasking to let them get work done while long, compute-intensive tasks run in the background. All these factors lead to a huge demand for memory. As this article was written, the clear standard was a minimum of 4 megabytes of RAM and 40 to 80 megabytes of hard disk space. Within 18 months, by early 1989, the new standard will probably be 8 to 16 megabytes of RAM and 120 to 350 megabytes of hard disk space. The workstation challengers from the personal computer world are in this ballpark, but so far they fall short, with only 1 to 2 megabytes of RAM and 20 to 40 megabytes of hard disk space.

All workstations offer multitasking through the OS and have hardware architectures to generate excellent multitasking performance. For instance, most new systems have cache memories for the CPU, with 8K bytes of cache now becoming a standard.

The first workstation feature that many engineers fall in love with is the large display. The least expensive systems sometimes have 15-inch screens, but 19 inches has become the standard. This large screen allows practical use of several windows at once. To make that possible, the screen resolution is typically in the megapixel range. This works out to about 1024 by 1024, with the Sun-3/50M offering 1152 by 900, the Apollo Domain Series 3000 having 1024 by 800, and the Domain Series 4000 offering 1280 by 1024. Personal computer systems such as the IBM PS/2 Model 80 and the Mac II have standard resolutions ranging from about 640 by 480 to 720 by 400.

While the least expensive systems produce monochrome displays, all the families also offer color graphics, with 4, 6, or 8 bit planes for color. The high-performance graphics workstations offer as many as 24 bit planes for color. Future low-end systems will no doubt imitate today's high-end systems and offer more bit planes for color or gray scale.

Software Layers

The most uniform facet of technical workstations is the OS. Almost all use some adaptation of Unix that combines System V features with elements of Berkeley 4.2. Apollo began with the proprietary Aegis OS, but later introduced Unix and admits now that almost all new applications programs for the Apollo are Unix-based.

Sun workstations have used Unix all along: One of Sun's four founders came directly from Berkeley and the Unix 4.2 project. DEC offers both Unix and VMS, its own proprietary OS, which has a long history in scientific computing because of the popularity of DEC's minicomputers.

The new entrants from the personal computer field, such as Apple and TeleVideo, realized the importance of Unix and are offering it alongside their own OSs (Apple's Mac OS and TeleVideo's version of MS-DOS). There are grumbles in the engineering community about the suitability of Unix for technical computing tasks, but there is little disagreement that it is the standard.

Most Macintosh users would quickly feel at home working on a workstation, for almost all systems employ a windowing manager for software. Two windowing environments are fighting for recognition as the standard. Sun is promoting NeWS (network-extensible windowing system), while Apollo, DEC, Hewlett-Packard, and many others are supporting the X Window System, a package created at MIT as part of the Athena project. Both of these windowing systems are network-based client-server systems and have the advantage over kernel-based windowing systems of letting tasks share displays in a network of heterogeneous machines.

A fast, integrated network is vital if you want to exchange complex graphics files between systems; to share expensive plotters, printers, large optical disks, and tape drives; to send electronic mail back and forth; and even to be able to upload CPU-intensive tasks to a minicomputer or other system in a hierarchy. Ethernet is a broadly used hardware standard for networking among workstations. But there are other networks, ranging from the inexpensive but slow AppleTalk of the Macintosh family, to the somewhat faster Token-Ring of the IBM clan.

In networking software, Sun has been fairly successful in turning its NFS (network file system) protocol into an industry standard. NFS lets different machines on the same network share files and messages. The Unix that most workstations employ offers an AT&T network protocol called RFS (remote file sharing). Apollo offers NCS (network computing system), a set of tools to help support data and program distribution across a network. DEC has the proprietary DECnet.

Because of the importance of networks, many workstation makers also produce servers—customized workstations dedicated to serving as a central node of a network. These systems have larger disks and memory configurations, as well as larger cache memories, than the regular workstations. Apple has software that transforms one of its systems into a server, but this doesn't match the performance of a hardware server. IBM's family doesn't offer a particular server either, whereas Apollo, Sun, and Hewlett-Packard have extended their families to include servers.

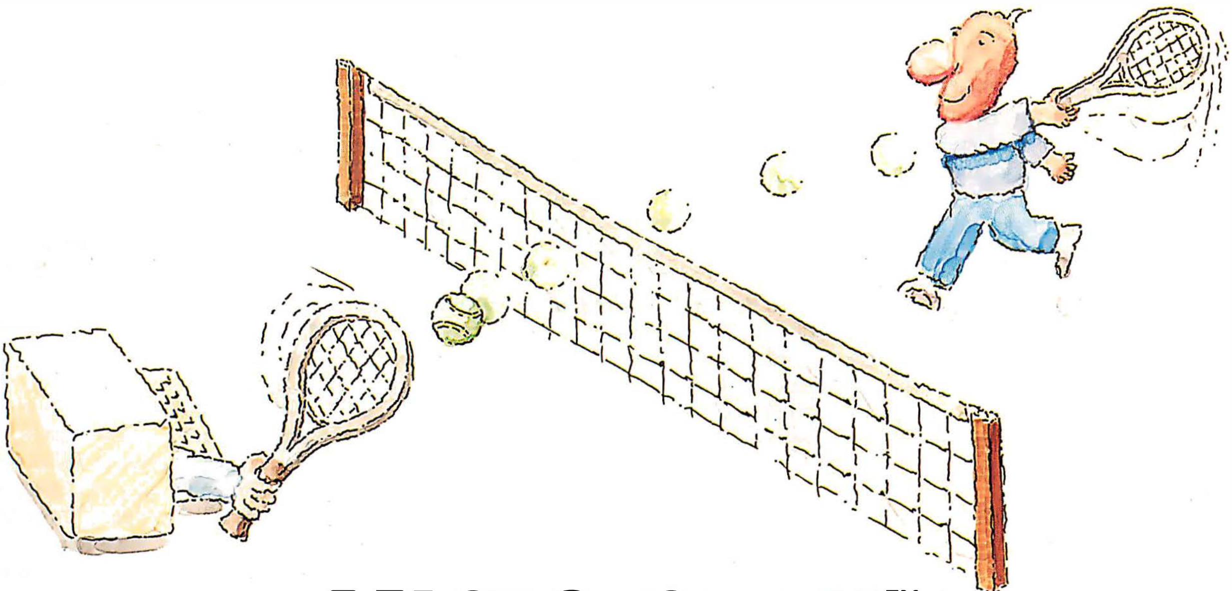
Workstations on Parade

There are three distinct subcategories within the general-purpose workstation market. At the bottom in price and performance is the personal computer, represented chiefly by the new 386-based DOS machines and the Macintosh II. In the middle are the low-end conventional workstations, machines that cost from $5000 to $20,000. At the top are the high-end graphics workstations, which are priced near or above $50,000 and offer color graphics performance beyond the ability of their low-end cousins.

Personal Computer Contenders

Although the 32-bit microcomputers of today, such as the Compaq Deskpro 386, the IBM PS/2 Model 80, and the Macintosh II, represent or promise a new performance level for microcomputers, in display resolution, network speed and integration, and OS, they don't yet have enough power to serve as technical workstations. But they remove some of the old memory constraints and closed architecture of previous systems. The hard disk size and CPU speeds almost qualify for workstations, and the memory space of the Macintosh could qualify, though currently the Macintosh doesn't ship with enough RAM.

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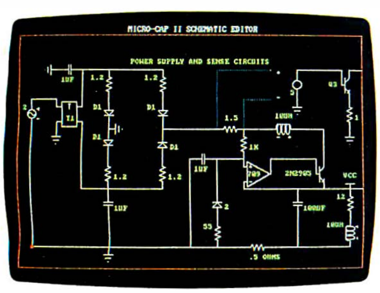


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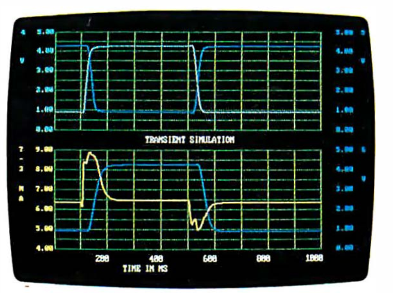
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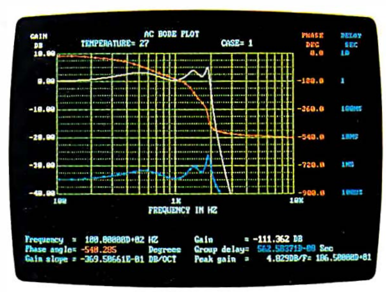
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The Mac II claims 2 MIPS of CPU performance from a 16-MHz 68020 and a 68881 FP coprocessor, and it comes with 1 megabyte of RAM and 40 megabytes of hard disk space. A version of Unix (A/UX) is also available for it. Two years ago those specs might have earned a place on the bottom rung of the workstation ladder; but even then, the slow AppleTalk network connection and 640 by 480 resolution on a 13-inch color monitor wouldn't have made the grade. Today, those features no longer quite rise to the level of the low-end conventional workstations, though they may help define a new sort of entry-level workstation.

The Model 80 offers superior disk data transfer rates and some other features that will help it pull away from other 386 systems, but it was not shipping in volume in mid-1987 and was waiting for an operating system, OS/2, that would release it from the 640K-byte RAM memory limit of DOS. The Compaq Deskpro 386 is in a similar boat, though the open architecture of both systems permits enhancement with add-on boards for disk storage, network interfacing, and high-resolution displays. TeleVideo's TeleSTAR engineering workstation is also built around the 80386, but it checks in with many of the characteristics of a conventional workstation, such as 4 megabytes of RAM and display resolution of 1280 by 1024 pixels. Its OS, Microport's DOS Merge-386, runs Unix System V.3 and MS-DOS concurrently.

The 80386 generation is also turning up in a new type of turnkey system. Computervision, for instance, one of the largest CAD/CAM vendors in the minicomputer and dedicated-system world, now offers a personal computer–based CAD/CAM system called the CV/386, built around a 386 DOS computer from Wyse Technology. The CV/386 is bundled with a software package from Computervision, such as Personal Machinist, Personal Engineer, or Personal Architect.

Intergraph, another big name in dedicated CAD systems, now sells its workstations as stand-alone units and is making a small workstation based on the National Semiconductor 32032 processor: the InterPro 32. Intergraph claims 1-MIPS performance and the ability to upgrade to 5 MIPS by replacing the 32032 with a Fairchild Clipper microprocessor.

Personal computer plug-ins or add-ons inhabit an IBM PC or Mac merely to use its power supply and disks. The Levco Prodigy systems can transform a Macintosh into a 68020/68881 machine running at several MIPS, and the Opus Series 300 Personal Mainframe puts a Fairchild Clipper chip set into an IBM PC box, claiming 4- to 5- MIPS performance. Definicon has created several add-in systems for IBM PCs and compatibles, such as the 68020 boards that have been profiled in BYTE.

Low-End Workstations

Four companies can together claim 80 percent of the low-end workstation market—Apollo, Sun, Hewlett-Packard, and DEC—and the first two captured the lion's share of even that 80 percent. Their systems have defined the standards and are used in applications from publishing to chip design. In mid-1987 these companies were busy cutting prices and introducing new hardware.

Sun Microsystems

The first big shot in the current workstation pricing war came from just north of Silicon Valley, when in April of this year Sun Microsystems cut the price of its least expensive system, the Sun-3/50M, from $7995 to $4995. That was for a 1.5-MIPS, diskless, monochrome 68020/68881 system with 4 megabytes of RAM and a built-in Ethernet interface. Disk-

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less systems such as this are more useful in a workstation environment than a diskless PC might be in most PC environments, because workstations are almost always networked, allowing access to a central hard disk.

Late in July, Sun announced the 3/60, a 3-MIPS color or monochrome system. The price of the system ranges from $7900 for a 1152 by 900 monochrome system to $12,900 for a color system with the same resolution. Until July, the Sun-3/260, which can operate as a standalone station or as a server, was the top of the Sun line, with a 25-MHz 68020, 20-MHz 68881, 64K-byte cache memory, and 8 megabytes of RAM. This was also the Sun system for high-end graphics work; it could be enhanced with graphics and FPAs (floating-point accelerators).

But the new top Sun system is the Sun-4 "supercomputing" workstation based on a new RISC microprocessor. This SPARC (scaleable processor architecture) chip set of a proprietary CPU and FPU, and two FPP chips from Weitek (the 1164 and 1165), run at 16.67 MHz and supposedly churn along at 10 MIPS and 1.6 MFLOPS (millions of floating-point operations per second). A memory cache and controller are also part of the architecture, which provides 1 gigabyte of virtual memory and as much as 128 megabytes of RAM.

In minimum configuration, the Sun-4/260 costs $39,900, though you can also upgrade a Sun-3/260 through a CPU board swap with a $13,900 kit. Sun will license the SPARC technology, and several chip companies have already planned to sell SPARC chips. The Sun-4 has a VAX/VME expansion bus and display resolutions of 1600 by 1280 for monochrome and 1152 by 900 for color. Even though it has a different CPU, the Sun-4 is source-code compatible with he Sun-3.

Sun is pressing its "open systems" philosophy with the Open Systems Network (OSN) to tie together all of Sun's products, its NFS file-sharing protocol, and its NeWS windowing system. These products apply to both the Sun-3 and -4 computers. Sun also offers the PC-NFS Programmer's Toolkit to let programmers develop multiuser, multisystem, networked applications that can bridge DOS and Unix on an Ethernet network.

Apollo

Apollo introduced the first workstation, the Domain DN 100, and for a long time was the leading seller of workstations. In 1987 Sun passed Apollo in revenues, but Apollo fought back by introducing the new Domain Series 4000 Personal Super Workstation and the DN 590 Turbo Graphics Workstation, and by halving the price of the Domain 3000 workstation family. The Domain 3000 Personal Workstation is about 2 years old and is based on a 68020 CPU and 68881 FPU with 4 megabytes of RAM, expandable to 8 megabytes. It runs the Apollo Aegis OS or Domain/IX, a Unix that blends System V and 4.2. The family also includes the DSP3000 Server with 4 megabytes of RAM, 348 megabytes of hard disk space, and 60 megabytes of tape space.

The new Domain 4000 Personal Super Workstation more than doubles the performance of the Domain 3000 series—to 4 MIPS—for the same price the 3000 held before the June price cuts. These systems have a 25-MHz 68020 and a 25-MHz 68881 FPU, with the same AT-compatible peripherals bus and Domain/IX Unix as the 3000. They add an 8K-byte virtual cache memory, 1 gigabyte of virtual memory address space, zero-wait-state operation, and RAM expandable up to 32 megabytes using 1-megabyte surface-mount dynamic RAM.

Apollo has also announced a $500 Domain/PC Emulator program that runs MS-DOS applications on any Domain system, and the Domain/PCI-Ring, a combination of hardware and software to connect a single IBM PC or compatible to the Apollo Token-Ring network. A PC using the PCI-Ring can then get at files and other resources on the Apollo network by using MS-DOS commands.

Hewlett-Packard

Hewlett-Packard equipment has been around laboratories for years, and more and more often that equipment included microprocessor-based controllers or computers. The HP 9000 family consists of a wide array of models, the most significant to the low-end workstation market being the 300 and 800 series. In the 300 series, the 318 is an entry-level, diskless, monochrome system that costs $7800. According to Hewlett-Packard, the cost will be lowered to $4990 by the end of summer 1987. The 330 series consists of midrange systems offered as server, monochrome, or color models. The HP 9000 model 350 was announced in November 1986 and started shipping in January of this year.

All the Series 350 systems use a 25-MHz 68020 CPU and a 20-MHz 68881 FPU, with a 32K-byte cache, a proprietary bus structure (a VMEbus adapter is available), and Hewlett-Packard's HP/UX Unix. The 350M is the basic monochrome model, with the 350CH and 350CX adding two-dimensional and three-dimensional wire-frame color graphics with a 4-plane frame buffer and a two-dimensional accelerator (60,000 2-D vectors per second, 45,000 3-D vectors per second) to the 350M base. Hewlett-Packard has also introduced its own RISC-based systems: The Series 800 model 825S is built on the new Precision Architecture CPU and runs at 8 MIPS.

Digital Equipment

DEC has been preeminent for years in hardware and software for technical and engineering workers. However, until 1986 it lagged behind in workstations, leaning more toward minicomputer solutions built around its VAX systems. But by putting the proprietary CPU of the VAX onto a chip, DEC was able to introduce the microcomputer-size MicroVAX and later the MicroVAX II. From the MicroVAX II, it built the 0.9-MIPS VAXstation 2000 workstation, with the MicroVAX processor, FPU, and 4 megabytes of RAM. This system runs microVMS (an operating system originally created by DEC for its minicomputers) or Ultrix (DEC's version of Unix).

In June 1987, DEC joined the parade and drastically cut VAXstation prices. It then claimed to have created the first 32-bit color workstation for less than $8000: a diskless VAXstation 2000 with a 15-inch monochrome monitor, 1024 by 864 resolution, 4 megabytes of RAM, and software costs $4600, while a color version costs $7900.

DEC also offered more powerful computers called VAXstation II systems, based on the same MicroVAX II platform. These ranged from the VAXstation II entry-level system with 2 megabytes of RAM, 71 megabytes of hard disk space, 95 megabytes of tape space, and a 19-inch monochrome controller to the AI VAXstation with 9 megabytes of RAM, 71 megabytes of disk space, 95 megabytes of tape space, and LISP. The VAXstation II/GPX line runs from a diskless color system with a 4-plane graphics controller and 5 megabytes of RAM up to the two-screen, 8-plane, color Ultrix system with 5 megabytes of RAM, two 8-plane graphics coprocessors, and two 19-inch monitors.

In early September, DEC announced two new workstations: the VAXstation 3200 and 3500. The new systems run at 3 MIPS and fit into the same network as older DEC workstations. The base-level 3200 is a monochrome, diskless computer with 8 megabytes of RAM. The 3500 can be configured with 16 megabytes of RAM, a 19-inch color display, and 8 bit planes for graphics. The announced performance and price place the 3200 and 3500 in the same range as the Sun-3/260 and the Apollo DN 4000.

The DEC systems run on Ethernet, and all DEC-compatible software runs on

continued

any of the systems. As a server, DEC offers the VAXserver 100, which is a MicroVAX II with an FPU, 16 megabytes of RAM, 456 megabytes of hard disk space, 95 megabytes of tape space, and a built-in Ethernet interface. The VAXserver can work in the Local Area VAXcluster, DECnet, or NFS/Ultrix environments.

After the big four, there is a second tier of companies that have a significant slice of the workstation market or have recently introduced machines backed by the experience and resources to grab a slice. These companies are listed below.

Masscomp

Masscomp specializes in real-time multiprocessor scientific workstations for collecting and analyzing data. This puts Masscomp computers in a slightly different field from the other technical workstations described in this article.

The Masscomp 5000 family of 68020-based systems includes the 5350 and the 5450, which can handle multiple users running RTU, Masscomp's real-time enhanced Unix that combines System V and 4.2BSD with virtual memory and real-time extensions. The 5450 has a 20-MHz 68020 and a 68881. It has a screen resolution similar to that of the 5350, but it offers optional vector accelerators and FPA hardware, along with greater RAM expandability and support for more simultaneous users. All 5000-family systems are Multibus systems.

IBM

Despite the marketing clout of its maker, the IBM RT PC didn't grab a big chunk of the workstation market after its announcement in early 1986. The 4.5-MIPS RT is based on a proprietary RISC microprocessor, the 32-bit ROMP chip.

There are several models of the RT, offering different RAM and disk options. All have both 8-bit and 16-bit expansion slots compatible with the IBM PC AT. There is a slot for an optional FPA that uses the National Semiconductor 32081 FPU chip. The RT can work with a variety of displays, including the Monochrome and EGA PC display adapters, the 12-inch Advanced Monochrome with 720 by 512 pixels, the 12-inch Advanced Color with 720 by 512 pixels of 16 colors from a palette of 64, and the 15-inch Extended Monochrome with 1024 by 768 pixels. The OS that ties the whole thing together is, of course, Unix. IBM supports the X Window System as a user interface for the RT.

Xerox

Xerox has owned a piece of the workstation pie since its Star computer, one of the inspirations for Apple's Macintosh line. The Xerox 228S technical workstation houses a 68020, a 68881, and 4 megabytes of RAM. Network support includes TCP/IP (Transmission Control Protocol/Internet Protocol) and XNS (Xerox network system) protocols. Unix is the OS.

NEC

Although it had been available in Japan for several months as the EWS-E, NEC's model 1500 was relabeled for its June introduction in the U.S. The 1500 is a 32-bit workstation running Unix System V and built around the 68020. It contains a 16.7-MHz 68020, a 16.7-MHz 68881, and a 68851 PMMU (paged memory management unit) chip. The 20-inch color monitor yields 1280 by 1024 pixels and runs NEC's MultiWindow Feature (MWS) environment, with a separate 68020 for window management with a drawing speed of 10K vectors per second. The optional High Graphics Feature (HGF) accelerator has four NEC image pipeline processors to support 256 colors from a palette of 16 million and a drawing speed of 75K vectors per second. The system runs Unix System V and can emulate an IBM 5080 graphics terminal, an option common to many of the workstations I've described.

Graphics Workstations

Three-dimensional solid modeling in tasks such as architecture, animation, CAM, fluid dynamics, molecular design, and aerospace simulation takes more graphics horsepower than standard workstations can harness. Thus arose the high-end graphics workstation. These systems often have the same CPU and general computer architecture as low-end workstations, but they have more memory for more bit planes (which translates into more displayed colors), along with specialized graphics-display accelerator hardware. In power or price ($40,000 to nearly $100,000), they don't impinge on the microcomputer market, so I'll only touch on them here.

The newest graphics workstation from Apollo is the DN 590 Turbo ($57,900), which takes a 68020/68881 base and adds a high-performance FPA and a graphics accelerator. The 3DGA graphics accelerator transforms and clips three-dimensional coordinates, in 32-bit FP format, at up to 130,000 vectors per second. It also can render 3000 to 5000 smooth-shaded Z-buffered polygons per second, and has double-buffering and 16-bit Z-buffering.

Optional graphics accelerators are available for the Sun-3/160, -3/260, and the -4/260 to make the CXP line of three-dimensional graphics workstations. The 4/260CXP ($57,900) is designed for three-dimensional, finite element analysis or interactive shading, while the 3/260CXP ($46,900) will do interactive wire-frame three-dimensional animation. The 3/160 ($32,900) is designed for two-dimensional work, such as VLSI layout.

The HP 9000 model 350SRX ($54,900) is also a 68020/68881 system with added graphics hardware. It has a three-dimensional accelerator that supports hardware Z-buffering for fast hidden-surface removal and Gouraud shading while performing 180,000 three-dimensional transformations per second. It has 4 overlay planes and an 8-plane frame buffer that can be increased to 32 bit planes. The Hewlett-Packard Series 800 model 825SRX ($69,500) is basically a graphics processor added to an 825S platform and is dedicated to high-speed bit-mapped graphics.

Silicon Graphics' IRIS Series 3100 combines a 68020 general-purpose CPU with a team of twelve 10-MHz real-time three-dimensional graphics processor chips that make up a "Geometry Engine." The Model 3130 can use 32 bit planes of image memory for Gouraud shading, depth-cueing, Z-clipping, and Z-buffering.

The Workstation Platform

As the technical workstation market has grown, the power of personal computers has also grown. In 1987, with the emergence of 80386-based personal computers (such as the Compaq Deskpro 386 and the IBM PS/2 Model 80) and the Macintosh II 68020-based microcomputer, personal computers began to rival and even beat the performance of the early workstations. Other companies, such as TeleVideo, introduced new systems based on the 386 chip—systems meant specifically to attract technical professionals. Yet workstation performance has kept ahead, as companies have moved to a new generation of speed and memory every 18 months and cut the prices of their low-end systems.

With more and more systems on the market, it is harder than ever to choose an engineering platform, but the systems contain as much computing power as the minicomputers of just a few years ago. As has been true since microcomputing began, what microcomputer users see in minicomputers and mainframes today, they can eventually expect to see on their desktops. What the technical workstations contain today will be the meat and potatoes of microcomputers within a couple of years. But then, with some of the recent price cuts bringing workstation prices under $5000, maybe there's no reason to wait even that long. ■

HARDWARE RESOURCES:

Adra Systems Inc.
59 Technology Dr.
Lowell, MA 01851
(617) 937-3700
Adra 1000 Custom CAD Workstation, proprietary CPU, AMD 29116 bit-slice graphics processor.
Inquiry 955.

Advanced Logic Research Inc.
10 Chrysler Ave.
Irvine, CA 92718
(714) 581-6770
80386-based enhanced PC.
Inquiry 956.

Altos Computer Systems
2641 Orchard Pkwy.
San Jose, CA 95134
(408) 946-6700
68020-based Model 3068, 30-user, Unix system.
Inquiry 957.

Apollo Computer Inc.
330 Billerica Rd.
Chelmsford, MA 01824
(617) 256-6600
68020-based Domain 3000, 4000, DN590 Turbo Workstations.
Inquiry 958.

Apple Computer Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010
68020-based Macintosh II.
Inquiry 959.

Arete Systems Corp.
2040 Hartog Dr.
San Jose, CA 95131
(408) 432-1200
68020-based Unix workstation.
Inquiry 960.

Aries Technology Inc.
650 Suffolk St.
Lowell, MA 01854
(617) 354-0900
Compaq Deskpro 386-based, integrated 3-D CAD system.
Inquiry 961.

Compaq Computer Corp.
20555 FM 149
Houston, TX 77070
(713) 370-0670
Compaq Deskpro 386, 80386-based PC.
Inquiry 962.

Corvus Systems Inc.
2100 Corvus Dr.
San Jose, CA 95124
(408) 559-7000
Series 386 80386-based network file server.
Inquiry 963.

Datapoint Corporation
9725 Datapoint Dr.
San Antonio, TX 78284
(512) 699-7000
Starship, Deskstar, MINX workstations, ARCnet.
Inquiry 964.

Definicon Systems Inc.
1100 Business Center Dr.
Newbury Park, CA 91320
(805) 499-0652
FAX: (805) 498-3559
68020-based drop-in boards for IBM PC, XT, AT and compatibles.
Inquiry 965.

Digital Equipment Corp.
146 Main St.
Maynard, MA 01754-2571
(617) 493-5153
DEC MicroVAX, MicroVAX II, and VAXstations.
Inquiry 966.

Hewlett-Packard Co.
1820 Embarcadero Rd.
Palo Alto, CA 94303
HP 9000 Series 300 68020-based workstations, HP 9000-8255 RISC-based workstation.
Inquiry 967.

IBM
(800) 447-4700
RISC processor-based RT PC, 80386-based PS/2 model 80.
Inquiry 968.

Japan Computer Corp.
One Bridge Plaza
Fort Lee, NJ 07024
(201) 592-6046
G-5068, G-5568, and G-5668, 68020-based workstations.
Inquiry 969.

Landmark Graphics
333 Cypress Run, Suite 100
Houston, TX 77094
(713) 579-4700
Intel 80286/80386-based Oil Exploration Workstation.
Inquiry 970.

Masscomp
One Technology Park
Westford, MA 01886
(617) 692-6200
MC5350, MC5450, and MC5550, 68020-based workstations.
Inquiry 971.

NEC Information Systems, Inc.
1414 Massachusetts Ave.
Boxborough, MA 01719
(800) 343-4419
NEC 1500, 68020-based workstation.
Inquiry 972.

Prime Computer Inc.
Prime Park, Mail Stop 15-70
Natick, MA 01760
(617) 655-8000
PXCL 5500, RISC-based 3-D graphics workstation.
Inquiry 973.

Pyramid Technology Corp.
1295 Charleston Rd.
Mountain View, CA 94039
(415) 965-7200
Pyramid 90 Series 32-bit processors.
Inquiry 974.

Renaissance Graphics Inc.
1050 Walnut, Suite 325
Boulder, CO 80302
(303) 443-0191
RGS 640, National 32000 Series CPU-based graphics workstation.
Inquiry 975.

Silicon Graphics
2011 Stierlin Rd.
Mountain View, CA 94043
(415) 960-1980
Iris 3030 proprietary CPU-based graphics workstation.
Inquiry 976.

Sord Computer of America Inc.
645 Fifth Ave.
New York, NY 10022
(212) 759-0140
680XX-based UNIX System V workstations.
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Sun Microsystems Inc.
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Mountain View, CA 94043
(415) 960-1300
Sun-1, -2, -3 (68020-based), and SUN-4 SPARC 32-bit RISC-based workstations.
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Tektronix Inc.
Information Display Group
P.O. Box 1000, MS 63/635
Wilsonville, OR 97070
(503) 682-3411
TEK 4125, 4128, TEK 4404 AI System, and other workstations based on various CPUs.
Inquiry 979.

TeleVideo Systems Inc.
1170 Morse Ave.
P.O. Box 3568
Sunnyvale, CA 94088-3568
(408) 745-7760
TeleStar, Unix-based 80386.
Inquiry 980.

Xerox Corp.
Xerox Sq.
Rochester, NY 14644
(716) 423-5078
Xerox 2285, 6085, 68020-based workstations.
Inquiry 981.

SOFTWARE RESOURCES:

Autodesk Inc.
2320 Marinship Way
Sausalito, CA 94965
(415) 332-2344
AutoCAD, CAD/camera, computer-aided design software.
Inquiry 982.

Celestial Software Inc.
125 University Ave.
Berkeley, CA 94710
(415) 420-0300
IMAGES-2D, IMAGES-3D, static and dynamic analysis.
Inquiry 983.

Conographic Corp.
17841 Fitch
Irvine, CA 92714
(714) 474-1188
ConoFonts printing/publishing software.
Inquiry 984.

Cranston/Csuri Productions Inc.
1501 Neil Ave.
Columbus, OH 43201
(614) 421-2000
computer-generated animation software.
Inquiry 985.

Cubicomp Corp.
21325 Cabot Blvd.
Hayward, CA 94545
(415) 887-1300
ModelMaker 3-D design/solid modeling software.
Inquiry 986.

Evolution Computing
437 South 48th St.
Tempe, AZ 85281
(602) 967-8633
FastCAD computer-aided design software.
Inquiry 987.

Prime Computer Inc.
Prime Park, Mail Stop 15-70
Natick, MA 01760
(617) 655-8000
Prime Medusa, multiuser CAD/CAM/CAE software.
Inquiry 988.

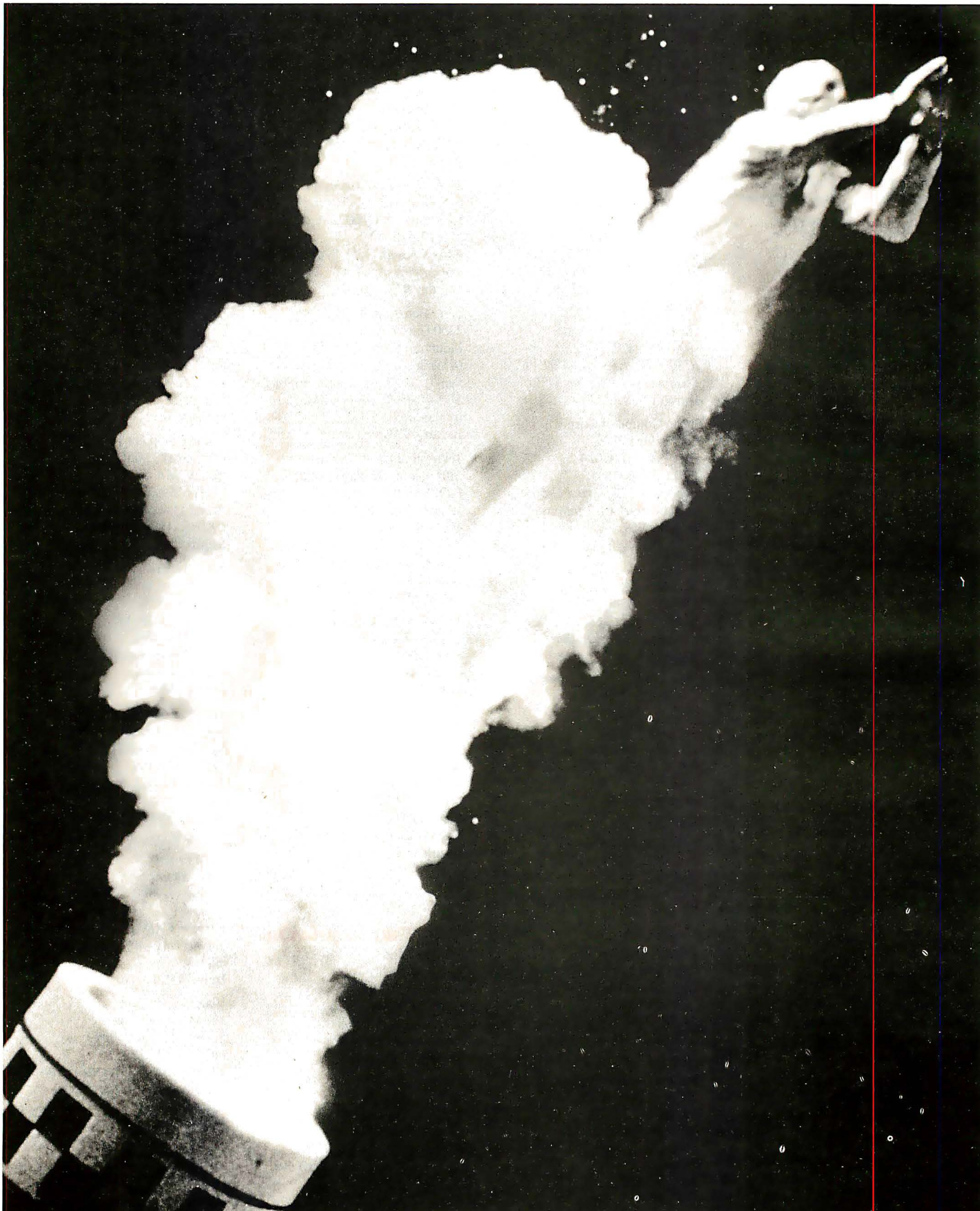
Robo Systems Corp.
3000 Cabot Blvd. W,
Suite 150W
Langhorne, PA 19047
(215) 750-6990
RoboCAD computer-aided design software.
Inquiry 989.

Template Graphics Software
9645 Scranton Rd.
San Diego, CA 92121
(619) 457-5359
Figaro, PHIGS draft standard implementation.
Inquiry 990.

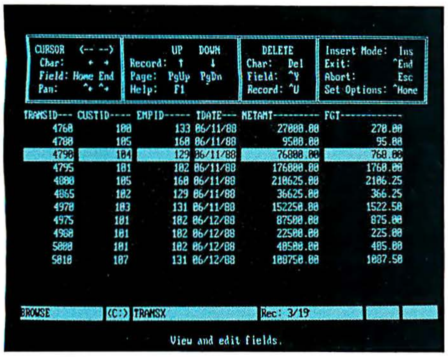
T & W Systems
7372 Prince Dr.
Huntington Beach, CA 92647
(714) 847-9960
VersaCAD, EasyCAD, general-purpose CAD systems for engineering workstations and micros.
Inquiry 991.

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Sunnyvale, CA 94089
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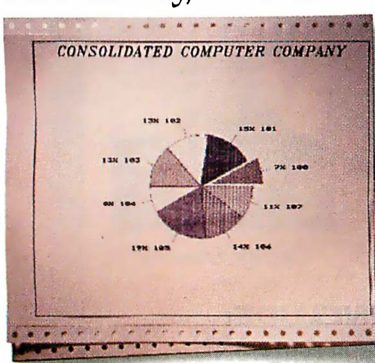
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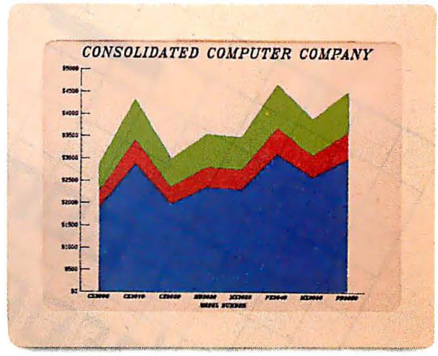
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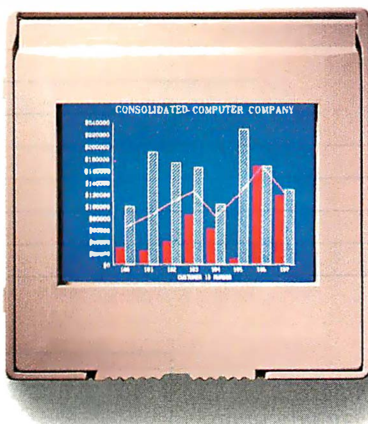
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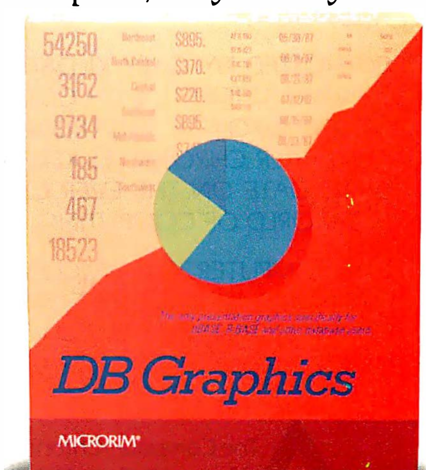
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Comparison of Window Systems

A look at the architectural differences between the Macintosh Toolbox, Microsoft Windows, the X Window System, and NeWS

by Hal L. Stern

INCREASINGLY, WINDOW systems are replacing the sequential user interface with an interactive multiple-process paradigm. Window systems are described by a desktop metaphor, where each window corresponds to a single sheet in a stack of papers on a desk. It is difficult to design a standard window system that will support both single-address-space and multitasking operating systems, stand-alone machines, and heterogeneous networks. Several complementary standards are emerging, each designed to incorporate the advanced technology of a particular computing environment.

In the world of personal computers, the Apple Macintosh Toolbox and Microsoft Windows are the dominant personal computer window systems. Both are kernel-based window systems, closely tied to their respective hardware. Recently, networked-based window systems have appeared, such as NeWS from Sun Microsystems and the X Window System from MIT, which allow a network of heterogeneous machines to share displays. These window systems require a multitasking operating system with facilities for interprocess communication. I'll compare the architecture of these four window systems.

The Window Layer

A window system is the system software that controls a bit-map display device and its associated input devices. It provides a high-level interface for applications, letting them paint and manipulate windows without delving into the lowest levels of the operating system. Applications are generally responsible for maintaining the contents of their windows, although some window systems cache obscured pieces of the screen. If an application's window is damaged by other applications, the window system will notify the application of the damage, but the application must repaint the current contents of the window.

Figure 1 shows the various components of a typical window system. The window system is responsible for rendering primitive graphics objects such as lines or text, managing the cursor position and front-to-back ordering of windows, and coordinating use of shared resources such as the mouse and keyboard. An application system, or toolkit, is layered on top of the window system and provides you with a library of routines for manipulating more complex graphical objects such as menus.

The toolkit may also include routines for access to the file system, memory manager, and data structures that can be used for communication between applications. Windows running background processes may be displayed as icons—images indicating the window's function but saving screen real estate for interactive applications. The interactive user interface to these components is the window manager, which lets you create, destroy, select, move, iconify, and communicate with windows on the display.

Flavors of Window Systems

Window-system architecture varies widely in terms of device independence, extensibility, imaging model, and integration into the operating-system kernel. The device-dependent portion of a window system is tightly coupled to the native hardware and operating system. A window system may be designed such that the device-dependent code is modular and can be modified without disturbing the user interface. A device-independent window system runs on many platforms but presents a consistent interface to the user. While a device-independent window system may be supported by many hardware vendors, it must abstract the capabilities of each display device to preserve semantics in each implementation. For example, color might be specified by a single integer on one machine, while the three (red, green, and blue) values are required by a second. The same window system will run on both machines only if it has an abstract notion of color contained in its device-dependent modules.

Extensibility refers to the ability to add new primitive operations to the window system. You can improve performance by bundling new functions into the window system, eliminating sets of calls to toolkit routines that perform the same task. You can also modify portions of the user interface in an extensible window system, replacing existing functions for mouse interaction, menu manipulation, and window selection.

An imaging model is the foundation for

continued

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In the client-server model, client requests are translated into machine-specific routines by the display server.

the window-system rendering routines. The pixel-based imaging model is the most common, as it can be implemented with a thin software layer between the rendering routines and the hardware. As the name implies, in a pixel-based system, objects are drawn by manipulating the pixels of the display. A raster transfer mode (or rasterop) determines how the rendered bits interact with the existing displayed bits: They can overlay the existing display, or the resulting bit can be the result of a logical function of the new bit and the existing bit. For example, a black line drawn with a logical-OR raster transfer mode would turn white background pixels black and leave black pixels alone. If the same line were drawn in logical-XOR mode, any intersection of the line and an existing line would appear white. While this approach is straightforward for monochrome displays, it isn't clear how raster operations apply to color displays, where each pixel is represented by an integer rather than a logical bit.

An alternative to the pixel-based method is a paint-and-stencil approach, in which objects are rendered as though spray-painted through a stencil of the appropriate shape. The "paint" used in this model is always opaque, so new graphical objects are always drawn "on top of" existing objects. Paint-and-stencil models solve the color problem created by pixel-based systems by eliminating direct interaction with the pixels.

Kernel-based window systems are tightly integrated into the native operating system and have the advantage of being able to access every kernel-level routine that affects the display or input devices. The penalty for such complete integration is a loss of device independence; kernel-based window systems are designed for a specific hardware platform and can't be easily ported to other machines.

A nonmultitasking environment such as the Apple Macintosh requires a kernel-based window system so that window-system toolkit functions are handled the same as other operating system calls. Multitasking operating systems let the window system migrate out of the kernel and become a scheduled process. When the window system and the application are separate processes, they may be best described using a client-server model.

Client-Server Models

Client-server relationships let several concurrent processes access a resource managed by the server. The server receives requests from clients and executes them, returning data when the client requires. The server process is a display server: It manages all interaction with the display device and input devices. Clients are user applications that request services by calling a routine in the programming library for the window system. The library routine packages the request and any parameters together and ships a "request packet" to the server. The server executes requests in a device-dependent manner. The interprocess communication mechanism that transports requests from the client to the server is transparent to the user. Several clients can make requests of the same server, and multiple servers can support multiple graphics devices on the same computer.

In effect, a display server provides a programming abstraction of the physical device. Clients can issue requests for generic services, which are translated into machine-specific routines by the display server (see figure 2). Because the device-dependent code is consolidated into the display server, a client-server window system is extremely portable. Once a server has been implemented for a machine, any application using the window system can be brought to the machine.

The interprocess communication mechanism that connects clients and servers can link processes on the same machine or over a network. Inherent in the design of a client-server window system is the ability to have the display server running on a remote machine while the client issues requests over the interconnection network.

Network integration is important in a heterogeneous computing environment of a few supercomputers and many workstations with high-resolution displays. Consider an environment in which several engineers share a supercomputer; all the engineers have workstations at their desks and can reach the supercomputer over a local network. The supercomputer may not have a high-resolution graphics device, or the display device may not be publicly accessible. Using a networked window system, it is possible to run a computationally intensive application on the supercomputer while viewing its graphics output on a workstation.

The abstraction provided by a client-server system lets many applications share the same display resource while executing on the hardware best-suited for each. If a company has proprietary software on one machine, or a large database that can't be duplicated elsewhere, these client processes can execute in their favored environments while using a local workstation as a display device.

Another advantage of the client-server window system is that many limits imposed by a kernel-based system are non-

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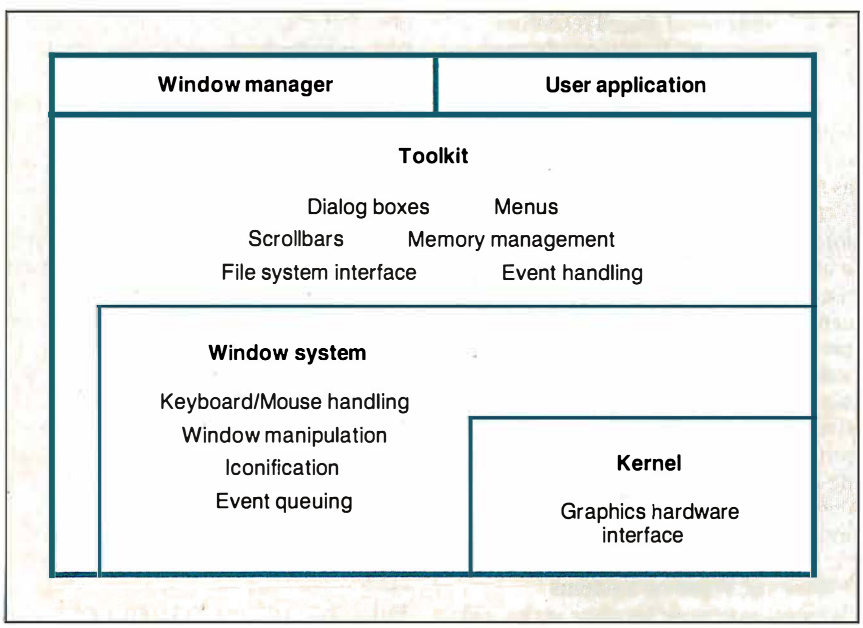
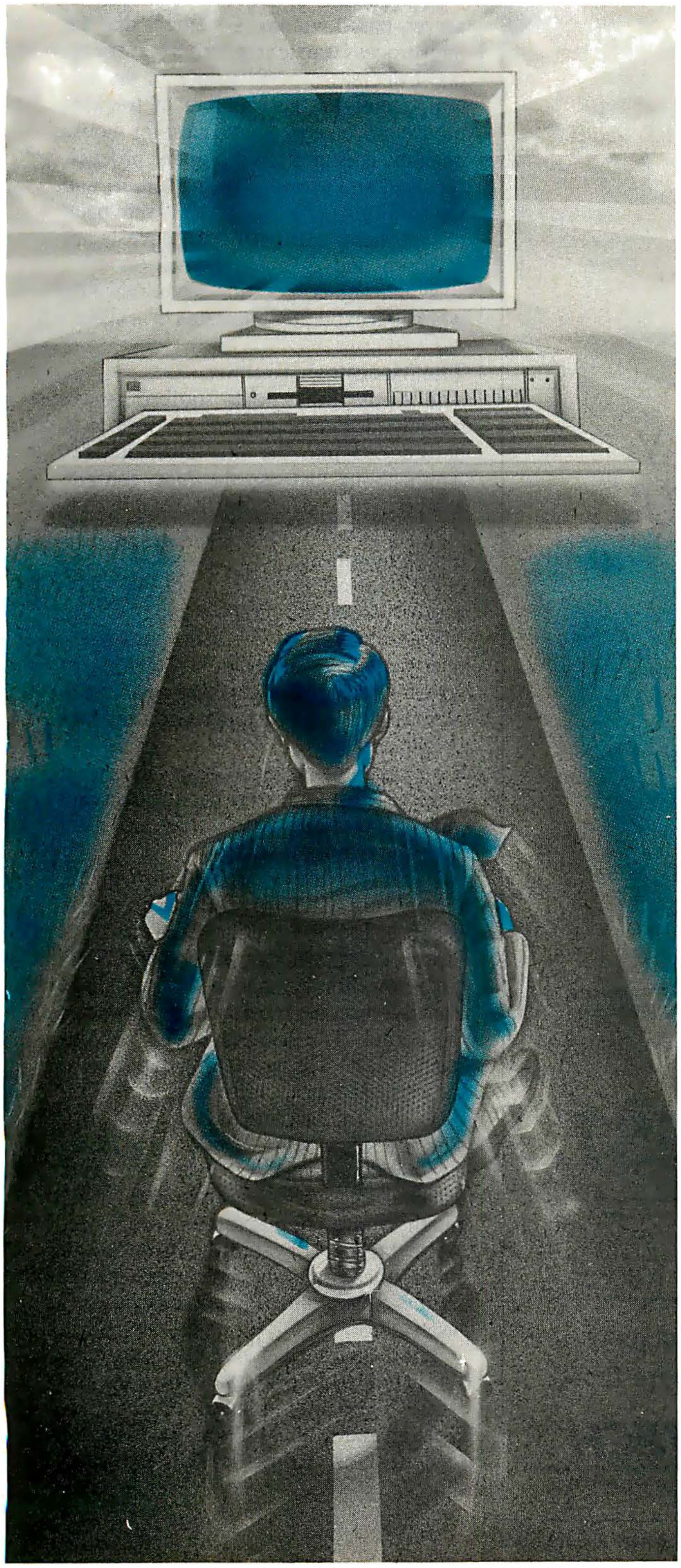


Figure 1: *Window-system architecture. A window system provides a high-level interface between the application and the hardware.*

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existent in the window server. A limit on the number of windows, for example, is usually imposed by a fixed table size in a kernel implementation. Window servers handle windows as abstract objects, and therefore an arbitrary number can be created, just as an arbitrary number of lines can be drawn in a single window. Resources can be named and shared by any number of clients of the server.

A criticism often leveled at client-server-based window systems is that the interprocess traffic required for every request decreases performance of the system. Consider the problem of tracking mouse movement: The request for mouse position is sent from the client process, received and executed by the server, and the resulting (x,y) coordinate is sent back to the client. Furthermore, requests are received and executed asynchronously, so synchronous operation is possible only when it is explicitly requested by a client.

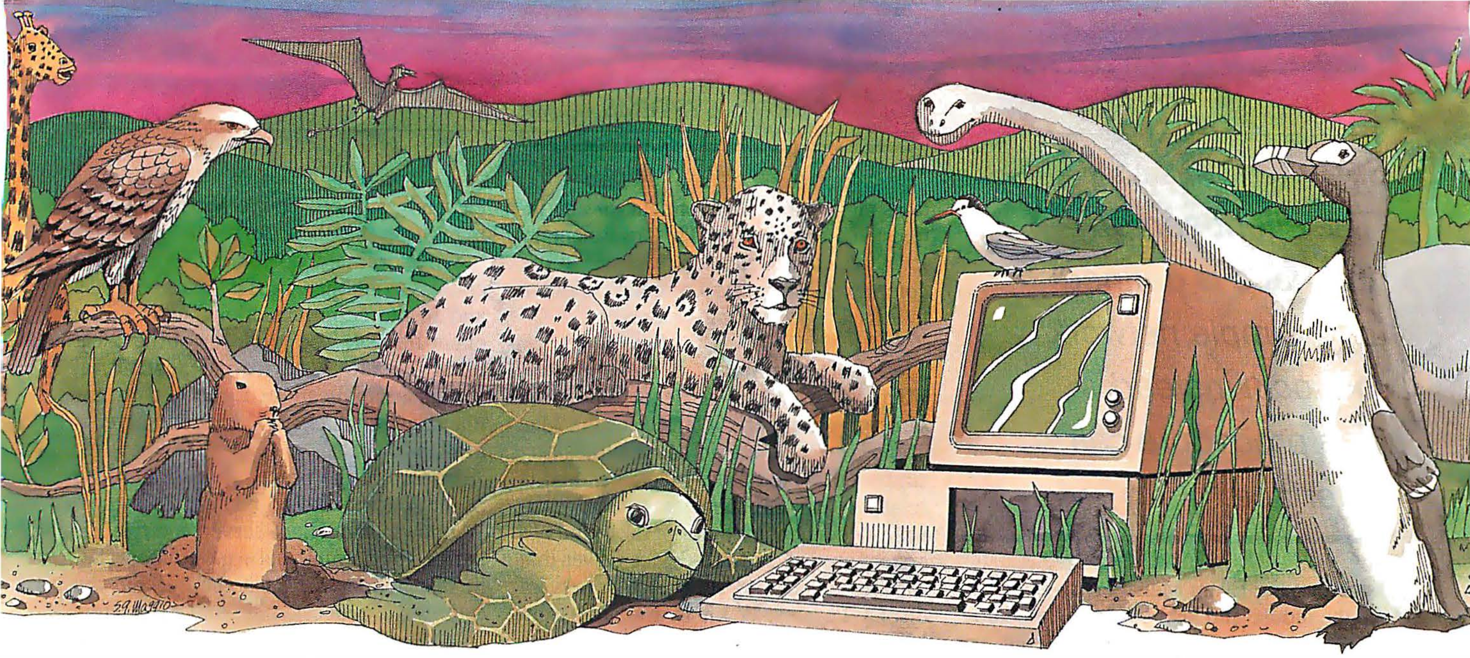
The Macintosh Toolbox

The Apple Macintosh Toolbox is extremely device-dependent because it is hard-coded into the Macintosh kernel. Applications that use the Mac Toolbox are restricted to life on the Macintosh; porting them to other window systems requires modifying the code and, in some cases, redesigning portions of the application. However, all applications on the Macintosh will use the same user-interface toolkit, resulting in a "Macintosh-style" set of applications that novices can learn easily. Many people find the Macintosh easy to use because applications share the same user interface: There is no need to learn a new set of keyboard and mouse operations to become proficient with another application.

Primitives are accessible through C, Pascal, or assembly language calls. When a Toolbox routine is called from Pascal, the appropriate parameters are set up by the library routine, and a trap is issued to execute the appropriate code in the kernel. The Toolbox calling mechanism is fast, due to its simplicity and to the kernel-based architecture of the Toolbox. The Toolbox and the application reside in a single address space, and therefore graphical objects and data structures can be shared without abstract data names. Furthermore, applications needn't include large programming libraries to access these routines, so programs take up less space on the disk and will load faster.

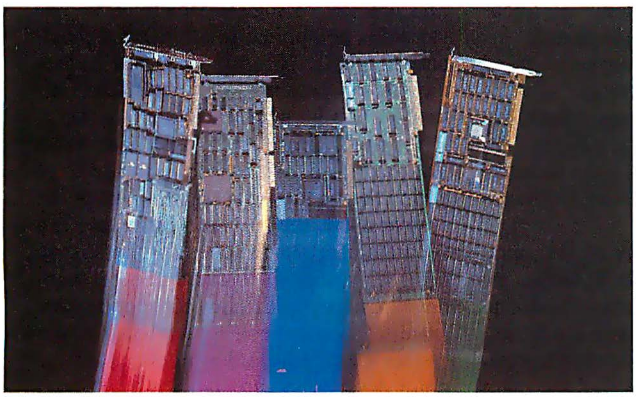
The Toolbox includes QuickDraw, a set of rendering primitives for many objects; the Font Manager, routines for creating and editing fonts and an interface to QuickDraw to provide text-rendering

continued



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The client-server interface is defined by a simple network protocol instead of a procedure call interface.

support; the Event Manager, an interface to the mouse and keyboard; and a Dialog Box Manager. The QuickDraw routines use a combination of pixel- and paint-and-stencil-based imaging models. Two applications can exchange data using the Clipboard, a scrap manager that maintains tagged fragments of data for any interested applications. This rudimentary form of communication replaces more complex interprocess communication in multitasking operating systems.

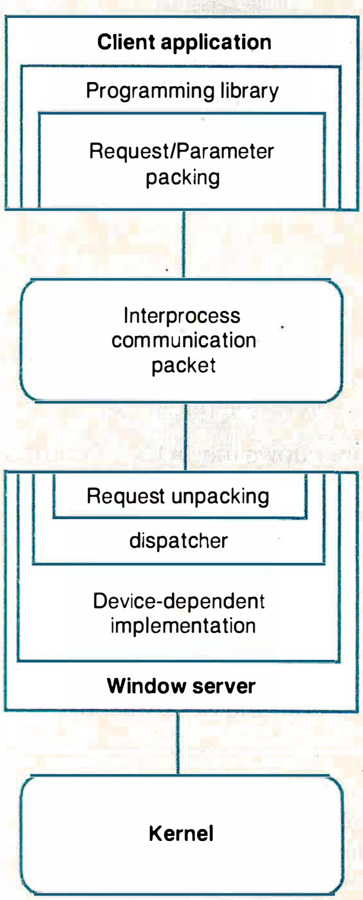


Figure 2: *Client-server relationship. The window server manages all interaction with the display device and the input devices. Clients are user applications that request services from the server through the window programming library.*

Microsoft Windows

Microsoft Windows presents almost the same programmer's interface as the Mac Toolbox. However, it has multitasking support lacking on the Macintosh and is relatively device-independent: The hardware-dependent modules of the Windows system are isolated in a device driver that can be replaced to support a variety of display devices. A kit is available from Microsoft to aid you in writing your own device drivers.

Windows runs under MS-DOS on IBM PCs and compatibles. The Windows code itself is started under MS-DOS, and it then creates a multitasking environment through message passing. Each application started under Windows sends and receives messages; when an application receives a message, it maintains control of the CPU until the message has been processed.

Windows performs message-routing and scheduling operations in a nonpreemptive fashion. All applications must abide by the message-passing rules so that no process gets an unfair share of processor cycles. This scheduling strategy differs from that of Unix, in which a process can be interrupted at any time if one with higher priority requires the processor. Messages can be sent from the keyboard or mouse, other applications, or the application itself. You can think of Windows as a large switchboard, routing messages to their destinations and queuing them until they can be processed.

The Windows toolkit is object-oriented in the sense that dialog boxes, subwindows, menus, and other applications are treated as message-passing objects. An application communicates with another object by sending and receiving messages through Windows.

Windows provides many of the same functions as the Macintosh Toolbox, including memory management and file system utilities, although these too fit into the object model. Windows routines can be called from C or Pascal, but the main procedure of an application must be given the name `WinMain( )`. This lets Windows locate the entry point of each application and take full control of the scheduling operations.

The X Window System

The X Window System was developed at MIT to meet the needs of Project Athena, a campus-wide networked installation of bit-map display devices. It is now in its eleventh revision. The X Window System is built on the client-server model, making it extremely portable. Nonportable code is contained in the server process and in the communications stubs of the client library. The top layer of the client library is entirely device-independent, allowing X applications to be run on any machine on which an X window server is available.

Instead of the procedure call interface of the Macintosh Toolbox and Microsoft Windows, the client-server interface is defined by a simple network protocol. Semantic actions for each request and the ordering of request codes and parameters in a network packet are defined by the protocol. The connection mechanism is built on top of a reliable asynchronous byte stream between the two processes, such as TCP/IP (Transmission Control Protocol/Internet Protocol) sockets in the Unix domain. The network-dependent portion of the client and server processes can be modified fairly easily, letting other transport mechanisms such as DEC's DECnet protocol be used in environments such as VMS where no native TCP/IP support is available. While X Version 11 will have extension "hooks," letting you define new request codes and associate server actions with each, the base implementation of X has a predefined set of server functions.

Routines in the programming library provide support for line and curve drawing; text handling; mouse, keyboard, and window-exposure event handling; font management; area filling; and some color support. Like Microsoft Windows, X uses a pure pixel-based imaging model that lets all 16 logical functions of two variables be applied to source and destination pixels. X itself does not have a toolkit for creating user interfaces, although one is under development for X Revision 11. In contrast to the Macintosh Toolbox and Microsoft Windows, in which the window manager is part of the system itself, the X window manager is a separate user-started client process. If so desired, you can substitute another window manager with new conventions for manipulating and selecting windows.

Device-dependent objects, such as color descriptors, are handled by abstract data objects. In the case of color, X provides routines for matching arbitrary red, green, and blue values to the closest color that can be realized on the physical display. The server implements the mapping of named color descriptors into color map entries for the display. All abstract objects are treated as resources managed by the display server. Since resource allocation occurs through client

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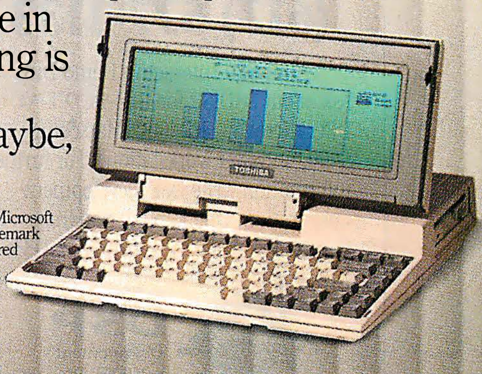
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requests, actions such as creating a window require a client-server round-trip. The client request will initiate the allocation; the server returns a descriptor of the allocated resource. Applications that make extensive use of resources (i.e., bit maps, windows, and fonts) are affected most by these round-trip delays.

The simplicity of the X interface makes it attractive for many applications. In addition, support for X exists on a variety of machines, ensuring that code written in one environment will migrate fairly easily to another that supports X. Also, because X is in the public domain, there is ongoing interest in the product and a steady stream of improvements, comments, and bug fixes from its users.

NeWS

NeWS, the Sun window system, has a client-server foundation similar to that of X. However, NeWS uses the paint-and-stencil imaging model of PostScript—an interpretive programming language used for graphics, and the native language of the Apple LaserWriter printer. The NeWS server is a PostScript program interpreter similar to the LaserWriter's but supporting Sun's extensions to the PostScript language for interaction with devices, event handling, and screen-oriented graphics primitives.

NeWS creates its own multitasking environment within Unix by scheduling and maintaining context information for each client process. These individual processes within the NeWS server are called *threads* or *lightweight processes*, a term derived from their lack of a complete process context.

While processes in Unix contain information about their virtual address space, interface to the operating system, and a full set of saved registers, all lightweight processes share a common address space. The scheduling process, therefore, need only save registers for each context to quickly switch from one thread of execution to another. The NeWS server manages all resources shared by the lightweight processes and can use its own scheduling algorithm to allocate processor cycles to each thread.

Clients in NeWS send entire PostScript programs to the server for execution; these programs can be calls to existing server code or to user-defined PostScript programs. The server views the output window as a PostScript device, interpreting client requests based on the state of each window. Clients can embed custom PostScript code in the server by defining PostScript procedures and then compiling them using Sun's C-to-PostScript compiler. At run time, these PostScript routines are loaded into the server as extensions of the basic NeWS system. They are accessible from the user's C program through a calling mechanism defined by the compiler. The user, therefore, can define any convenient extension to NeWS and include it in the window system.

NeWS provides an object-oriented approach to user interfaces similar to that of Microsoft Windows. As in X, no specific toolbox routines are provided for menus, controls, or dialog boxes; however, a framework is provided in which they can be quickly prototyped and incorporated into client applications.

NeWS is currently supported only on Sun workstations; Sun has highly optimized the server to be an efficient PostScript interpreter. Sun has announced a merged X and NeWS window system that will support both the advanced imaging model of NeWS and the standards of X. Applications on the Sun will be able to use either window system in a full implementation; Sun's X port will be a native X window server and not an emulator layered on top of NeWS.

Selecting a System

Window systems have gone a long way to improve user interfaces. Kernel-based systems such as the Macintosh Toolbox and Microsoft Windows provide extensive toolkits to promote uniform user interfaces. While this makes it easy for you to learn new applications after mastering the operation of the mouse and keyboard, it assumes that one interface style is appropriate for all applications. Also, as users become more proficient with some applications, they may find verbose interfaces or frequent pop-up windows an annoyance. Extensible window systems, and those in which the user interface can be modified, circumvent the "advanced user" problem.

The end users are the determining factor in the selection of a window system: Novices using many software packages will appreciate consistent user interfaces, while software developers and advanced users will want to tailor their working environment to meet their needs and personal preferences. ■

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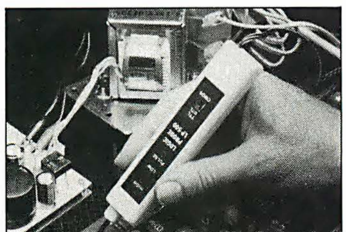
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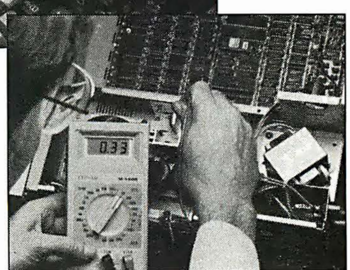
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FIFTEEN YEARS AGO, sophisticated use of computer graphics existed only in the most highly funded high-tech institutions, such as national laboratories and scientific parks that provided research for the automobile, chemical, communication, and energy industries. Today, as a result of workstation advances, computer graphics technology is used in most aspects of engineering, scientific research, academic study, and daily business. Graphics products are widely available, and their price-to-performance ratio is constantly improving.

But many companies that now enjoy the efficiency and informational value of computer graphics are overwhelmed by the diversification and incompatibility of graphics solutions used within different groups in the same organization. For example, programmers within the same group develop similar applications based on different computer graphics software, because each is familiar and productive with his or her own favorite graphics tools. This type of problem is analogous to those in other advancing technologies. Try to imagine writing and publishing an encyclopedia with a staff of 30 writers, each using a favorite word processor—except for the one who prefers a typewriter. This type of chaos now exists in many organizations that use graphics tools, and it will only worsen unless the fundamental levels of computer technology and practice are standardized.

[Editor's note: *Many articles and publications about PHIGS are now available. The book* Understanding PHIGS *by Maxine Brown and Mike Heck describes in detail the philosophy and workings of the PHIGS system. The NCGA's* Standards and the Computer Graphics Industry *covers past and present work on graphics standards, with a brief description of the scope and application of the most popular standards in use today.*]

A Device-Independent Standard

Standards for programming languages and graphics tools have many benefits. Common practice can be taught, refined, and reapplied to subsequent projects, coordinated with other organizations, and easily interfaced to smaller or larger systems.

Device-independent standards let programmers concentrate their primary effort on developing applications. Many mundane tasks previously included in applications programs, such as data storage and manipulation, would be handled by the support system defined in such a standard. Further, an educated group of users becomes a long-term resource, maintenance of software becomes manageable, and new projects can be estimated, scheduled, and monitored with more accuracy due to relevant experience.

Developing a technology standard is similar to defining, building, delivering, and supporting a successful commercial product. Graphics standardization has been an ongoing activity on a national and international level since the 1970s. The ANSI and the ISO have specialized subcommittees whose charter is to develop the specifications for various functional levels of computer graphics.

The ANSI X3H31 committee, known as the PHIGS committee, has been working on a computer graphics specification that addresses three-dimensional modeling of hierarchically defined objects, rapid manipulation of geometric and rendering attributes, and interactive input. The committee members are employees of companies representing end users, applications developers, and suppliers of software tools, graphics hardware, and computers.

The PHIGS Specification

The Programmer's Hierarchical Interactive Graphics Standard (PHIGS) is a detailed description of graphics functions, error conditions, and FORTRAN, C, and Ada language bindings. It is intended to provide a common programming base for graphics hardware and applications program developers to minimize time and energy lost dealing with incompatible systems and technology.

Currently, the draft proposed standard is being publicly reviewed for comment and completeness. Adoption of PHIGS as a standard by ANSI and ISO is expected in 1988.

Another group, the PHIGS+ committee, is an ad hoc committee to develop compatible extensions to the ANSI PHIGS draft proposal. Its focus is to de-

continued

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The interaction handler is the most complex of the four major PHIGS components.

fine extensions to PHIGS that address curves, curved surfaces, shading, lighting, direct color specification, and depth cuing. The PHIGS+ committee, consisting of approximately 20 computer graphics experts, has been working since November 1986 to develop a detailed specification incorporating known practice in these areas.

Architecture

PHIGS, as defined by the PHIGS standard, can be previewed in brief by subdividing it into the four major components shown in figure 1: the control center, the data definition system, the data display system, and the interaction handler.

The control center maintains the state of the entire graphics system and monitors access to the other subsystems. The data definition system controls the construction, manipulation, editing, archiving, and retrieval of graphical objects called *structures*. The data display system controls access to the graphics display device (terminal, plotter, and so on) and manages the traversal (display) of the structures that have been designated for display.

The interaction handler is the most complex of the four PHIGS components. It manages interactive input processing and graphics hardware resources, and it provides instructions to the data display system to update the display. The interaction handler also supplies information to applications programs so that the data definition system can be used to modify structures.

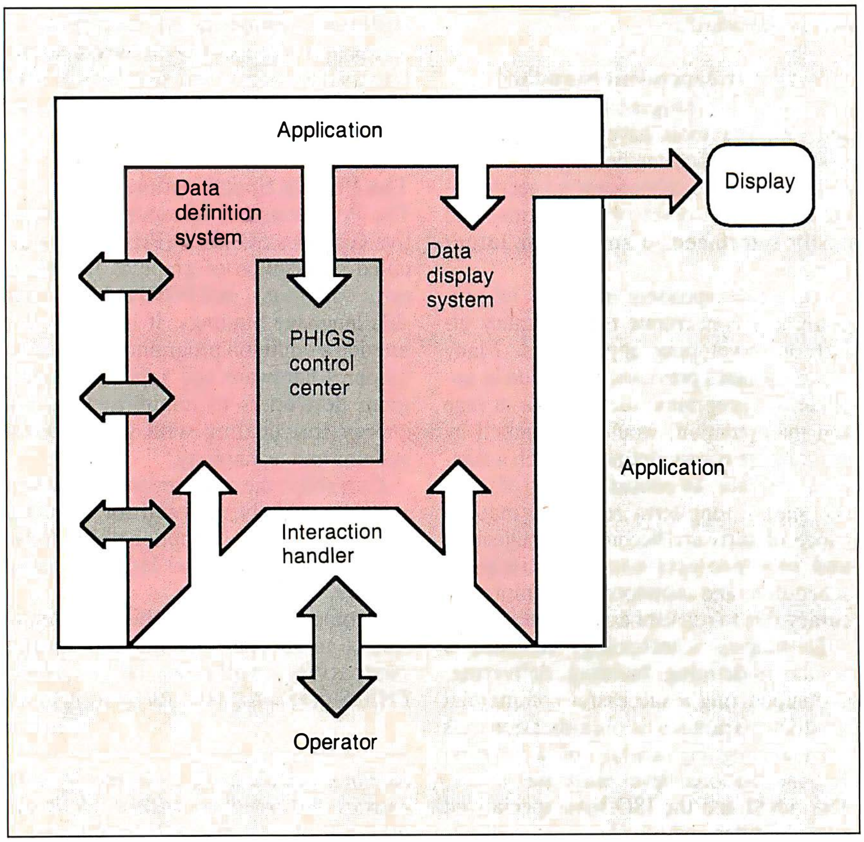


Figure 1: *A block diagram of the PHIGS subsystem.*

Control Center

The PHIGS control center maintains the global system state and the opening and closing of subsystems. PHIGS can be viewed simplistically as a finite state machine (see figure 2). The `Open PHIGS` control function initializes the system; the `Close PHIGS` function closes it. `Open` (graphics) `workstation` opens the connection to a graphics display device and initializes it for graphics output and input.

On an engineering workstation, the graphics display device is usually a process window dedicated to graphics output and input. The control function `Close workstation` disconnects the graphics display device from PHIGS. Some implementations may choose to let the graphics image remain visible on a closed display. Others, such as engineering workstations, may close and release the process window dedicated to graphics, thus removing the graphics image from the physical display surface.

`Open structure` invokes the PHIGS graphical database editor and allows the passage of information to and from the data definition system. `Close structure` releases the editor and stops the passage of information.

The `Open archive` function permits the data definition system to read and write geometric models between the internal database of PHIGS and external permanent files maintained by the computer's operating system. The PHIGS archival subsystem also has a respective `Close archive` function.

Data Definition System

The data definition system is the modeling and object-construction toolkit of PHIGS. The data definition system contains a central database, an editor, and archival utilities. The database consists of structures, which in turn are collections of atomic entities called *structure elements*—the fundamental building blocks of graphics objects.

Structure elements include three-dimensional geometric primitives, their respective primitive attributes, view-specification indexes, modeling matrices, structure instances for creating hierarchical structure networks, labels, namesets (i.e., relational classification identifiers), pick identifiers, and applications data records.

Geometric Primitives

The geometric primitives included in PHIGS are polyline (a set of connected lines), fill area (a polygon, hollow or filled, without edge control), fill area set (a polygon, hollow or filled, with edge control), polymarker (a set of locations, each indicated by a marker), text, and cell array (a rectangular grid of equal-size rectangular cells of a uniform color (see figure 3).

All primitives are three-dimensional; two-dimensional shorthand specifications are provided for applications that define planar objects. (The applications specify primitives in two dimensions, and PHIGS will automatically specify the third dimension by setting the *z* component internally to zero.)

The attributes for these primitives are segregated by primitive type. This means that attributes are not shared between primitives (see the text box "Segregated-At-

continued

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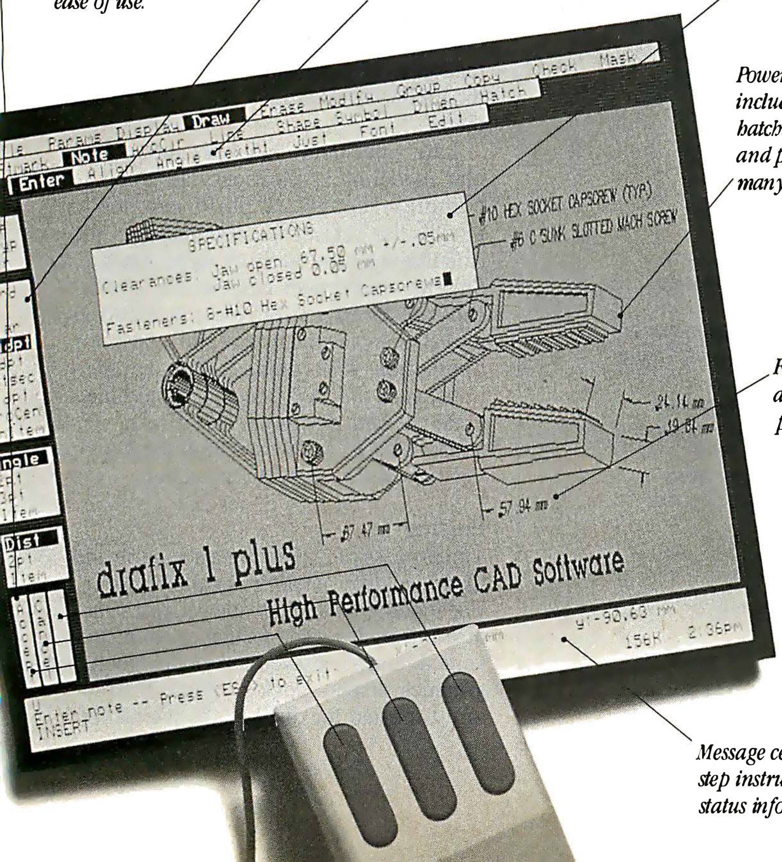
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tribute Model" on page 282). In some graphics systems, for example, setting the color affects subsequent lines, polygons, and text. In PHIGS, setting the line color has no effect on text or polygons. Likewise, setting text color does not affect lines or polygons.

Central Structure Storage

The PHIGS graphical database is a simple file system called the *central structure storage* (CSS). The *structure editor* controls the passage of definitional information between an application and the CSS. The CSS contains all object definitions that can be displayed, modified, and archived.

For purposes of explanation, we can view the CSS facility as a simple text file system, view each structure (i.e., object) as a text file within the file system, and view each structure element as a line of text within a text file. Since structures are linear lists of structure elements (i.e., sequential lines in a text file), the structure editor is analogous to a simple text editor whose current line pointer can be positioned at any line (i.e., structure element), after which new information can be inserted and at which existing information is deleted.

Building an Object

Building objects with PHIGS is a straightforward process. A complex object such as an automoble, airplane, or ship can be broken down into logical groups connected in a hierarchical manner. An application can establish the amount of detail to be defined at each level in the hierarchy and then begin to specify each accordingly. PHIGS permits both top-down and bottom-up construction of hierarchical objects.

For example, one application might choose to define an automobile by first defining all the atomic parts—nuts, bolts, flanges, rings, pistons—and then constructing large components, such as wheel assemblies, by instancing previously defined atomic parts. Another application might choose to define the automobile from the top down: defining the drive train, body exterior, body interior, and so on, then iteratively breaking down each group into smaller groups.

Defined structures can be archived so that they can later be retrieved by the same or other applications. The PHIGS archival utilities are part of the data definition system and manage the transfer of structures between the internal file system of the PHIGS CSS and the external file system maintained by the operating system.

Geometric parts libraries for automobiles, aircraft, and ships are excellent applications for PHIGS and its archival utilities. Applications can retrieve thousands of atomic parts easily and then construct a complicated object from atomic geometric components.

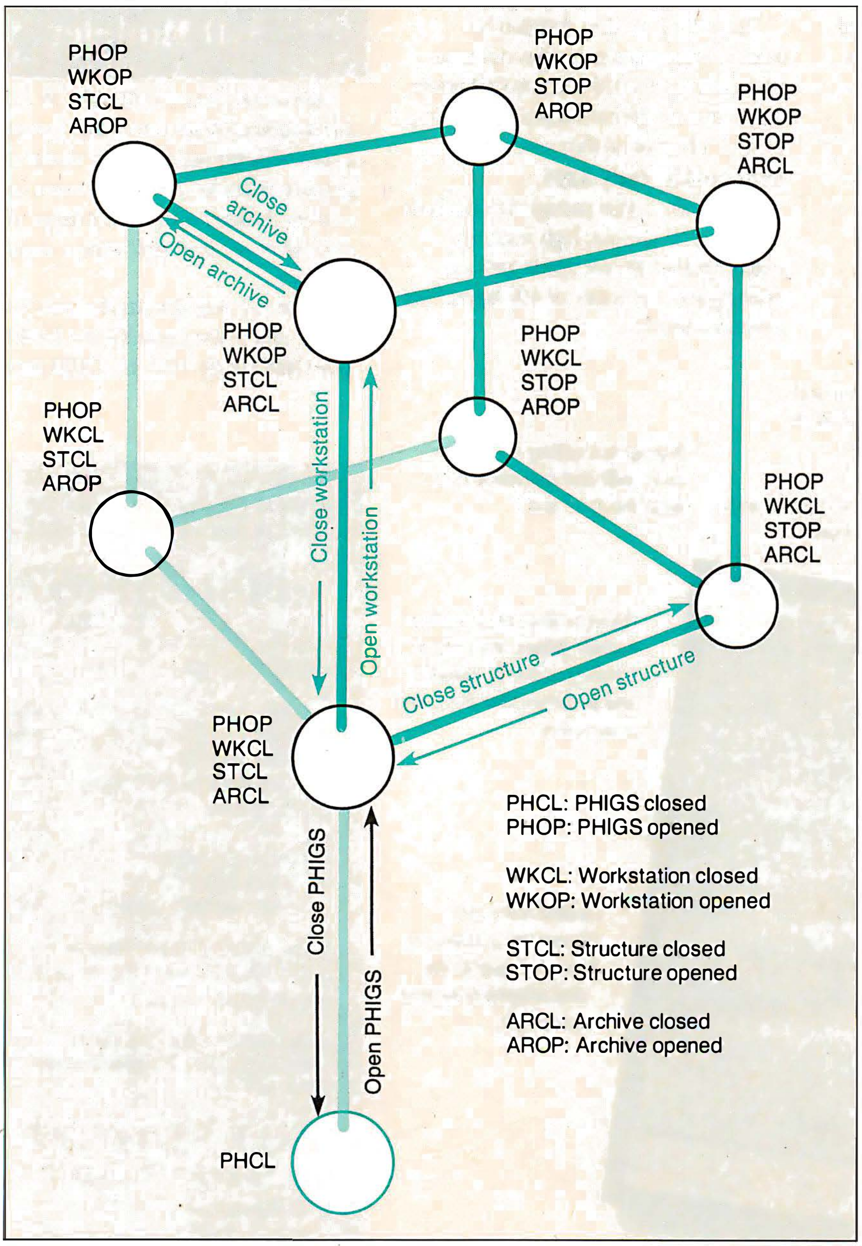


Figure 2: *A block diagram of a PHIGS control center.*

Data Display System

PHIGS separates the processes of data definition and data display. This separation permits the design of applications that only compute and build models using the PHIGS framework without displaying them.

Large mechanical analysis and molecular modeling applications can compute complex scenarios, build geometric models that reflect specific phases of the calculations, and archive these models. Smaller applications can then be specifically designed to retrieve the archived models, display them, and allow operator interaction with them. Other applications, such as CAD systems, tightly integrate the data definition and display systems. This is easily accomplished with PHIGS via the interaction handler.

Posting

The process of displaying a structure and its descending network is called *posting*. The function `Post root` identifies a structure and its descendants that are to be traversed and displayed on a designated graphics display device. While a structure is posted for display, the interaction

continued



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handler keeps track of activity occurring within the data definition system and the data display system. When an activity occurs that renders the current image of a posted structure network obsolete or out of phase with its hierarchical representation maintained in the CSS, a retraversal is requested to update the display.

The function `Unpost root` removes a specified structure network from the list being displayed and updated. During unposting, the image of the specified structure network is removed from the display. An additional function, `Unpost all roots`, is a natural extension of `Unpost root`.

Interaction Handler

The interaction handler controls several types of interactions. It controls interaction of workstation input peripherals, such as a mouse or keyboard. It controls the time that the image of an object is to be made current due to changes made within the data definition system or changes made to the data display system. It also manages available workstation resources, such as the color table, screen space, and interaction with the window manager.

The interaction handler controls physical input peripherals, such as a trackball, joystick, mouse, dial box, and keyboard, via a logical input model. The PHIGS model defines six logical classes of input devices: Locator, Stroke, String, Choice, Valuator, and Pick. Each logical input device is mapped to a physical device.

The Locator and Stroke classes are logical pointing devices and return positional information to the graphics system and applications program. This information is of the form (x,y) ordered pairs or (x,y,z) ordered triples. The Locator device returns a single position. The Stroke device returns several positions.

A String device is used to return textual information to the graphics system and application. Usually, String devices are mapped to a physical keyboard on which the operator can type desired character strings. The Choice device is used to designate a choice from several available options. It is usually mapped to a function pad or button box and returns information of the form "button 13 was pressed."

The Valuator device is much like a light dimmer. It returns a value between a

continued

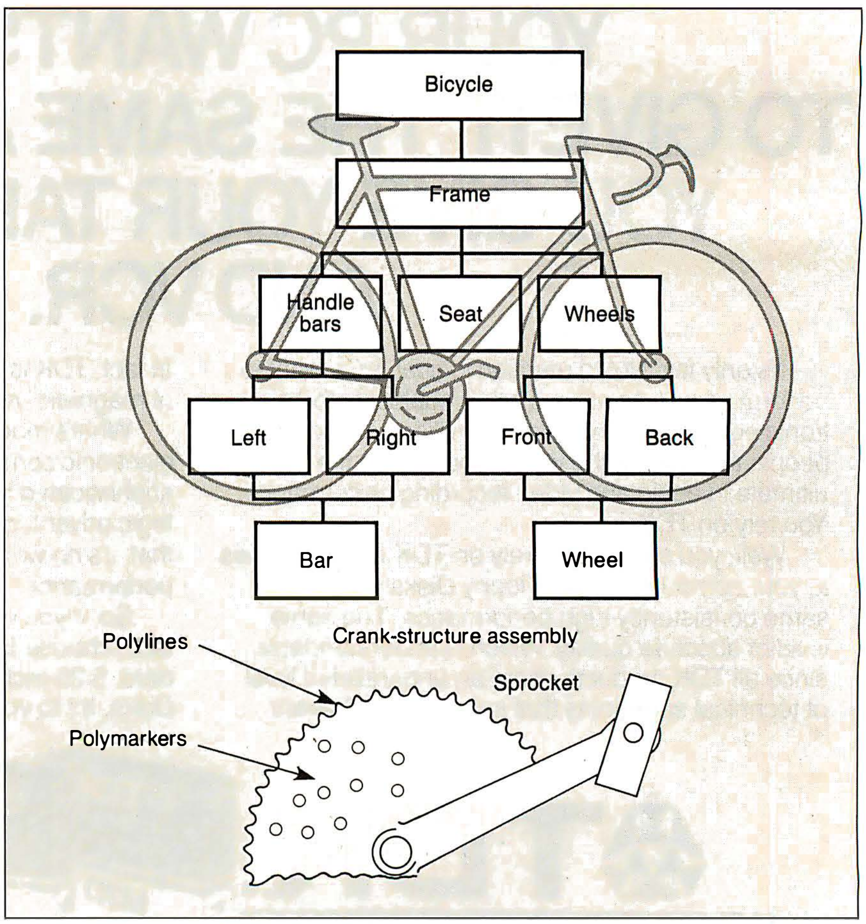
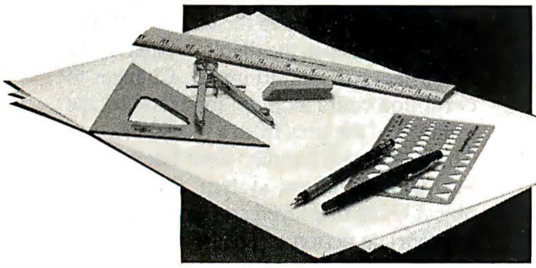


Figure 3: *A hierarchical data organization, showing graphics primitives and structure elements.*

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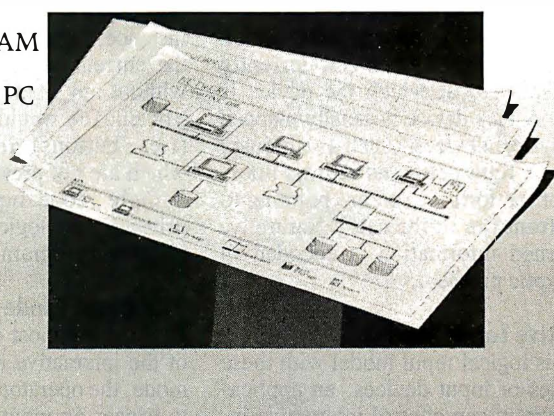
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Segregated-Attribute Model

PHIGS employs a segregated-attribute model to simplify and concentrate model construction on geometric primitives and not on the ordering and interaction issues of global attributes and primitives. Each geometric primitive in the PHIGS system has its own set of dedicated attributes that determine its appearance. (See figure below.)

Polyline

Set line color
Set line type (line style)
Set line-width scale factor (line width)

Polymarker

Set marker color
Set marker type
Set marker scale factor

Fill area

Set interior color
Set interior style
Set interior style index

Fill area set

Set interior color
Set interior style
Set interior style index
Set edge existence flag
Set edge color
Set edge type (edge line style)
Set edge-width scale factor
(edge line width)

Text

Set text color
Set text font
Set text precision
Set text path
Set text alignment

Set character expansion factor
Set character spacing
Set character height
Set character up vector

Cell array

(No attribute settings)

definable minimum and maximum value. A Valuator device is usually mapped by the interaction handler to a dial box (a mouse-, joystick-, or light pen–actuated analog control, displayed on the screen).

The Pick device returns information regarding the part of an object, currently being displayed, at which the device is pointing. A Pick device is usually mapped to the physical devices—such as a mouse, joystick, or light pen—and returns information of the form, "You are pointing to the left front tire of the car." Naturally, the returned information is encoded in more cryptic protocol.

Interactive Input Modes

Using this logical input model with these six classes of input devices, an applications program can control interactive input via three modes: Request, Sample, and Event.

Request requires the application's operator to take some action to trigger the input report. For example, a Request Locator would require the operator to press a mouse button before the (x,y) position pointed to by the mouse would be returned to the interaction handler. A Request String could require you to press a carriage return after entering text from the keyboard.

Sample mode input requires no operator interaction. In this mode, the applications program simply retrieves the current measure of the logical device. For instance, `Sample valuator` would return the current value of a dial immediately without any operator intervention. `Sample choice` would return which choices (i.e., buttons) are pressed down and which are not pressed. Both Request and Sample mode input are procedurally driven by the logic designed into the applications program.

The Event Mode

Event is the most complex and powerful of the interactive input modes. In Event mode, the operator must take some action to trigger an input report. This action—an input event—is then placed in a first-in/first-out queue containing the class of input and a packet that includes the information the particular input class provides.

The application requests information from the event queue, determines from the event report which input class generated the event, and takes the appropriate action to process the information packet provided by that logical input device. Event mode is used to let an application be operator-driven rather than procedurally driven. Event-driven applications are usually more user-friendly because input sequencing is defined by the operator and not the applications developer.

The interaction handler also assists the traversal (display) process. It detects when the display surface is to be updated because of changes in the object's definition or changes in the display system itself that affect a displayed image. Changes to definition could include, for example, the removal of the tires from a model of a car. The interaction handler would detect that the data definition system changed the object being displayed and would take the appropriate action to ensure that the displayed image correctly reflected the object's current definition.

Changes in the data display system can also cause traversal for the purpose of correcting an image on the display. For example, panning around and zooming in or out on an object can be accomplished by changing viewing information maintained by the data display system. In this example, the definition of the object has not changed, only the manner in which it is being displayed. The interaction handler detects the change and requests retraversal after internal transformations have been adjusted to yield the effect of pan and zoom.

Window Manager

Engineering workstations require close integration with the window manager. An operator must be able to push and pop process windows, resize the graphics window, and move freely from one working process to another. The graphics system must be aware of the window manager and track changes in the workstation windowing environment. Window managers are classically event-driven systems from the operator's point of view. The graphics system needs to ensure that when events affecting the graphics environment occur, appropriate action takes place.

For example, an object is displayed within a process window dedicated to graphics; the operator resizes and repositions that window so that other work (e.g., editing a data file or document) can be done in another process window that requires more screen space. The interaction handler within the graphics system must detect that the physical screen space allocated for graphics has now changed; internal base transformations are adjusted and retraversal of the object is requested to correctly display the object in a smaller process window now located at a different position on the physical workstation

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display. The interaction handler manages this required interaction.

Extensions to the Standard

Graphics functions that address shading and lighting were not included in the original PHIGS specification. But many applications now require this capability, and several high-performance graphics workstations provide it: the Apollo 590, the Sun CXP series, the Hewlett-Packard SRX series, the Silicon Graphics Iris and 4D, and the Prime PXCL 5500.

The PHIGS+ specification defines a set of compatible extensions to the ANSI PHIGS specification to address lighting and shading by incorporating additional geometric information. This information is in the form of vertex normals, vertex color specification, surface properties, and new geometric primitives that represent curves and curved surfaces. PHIGS+ specifies lighting and shading models that let applications render realistic images of models defined using both PHIGS and PHIGS+ primitives.

The PHIGS+ primitives and attributes follow the philosophy of PHIGS and maintain the segregated-attribute model. These new geometric primitives and attributes are structure elements much like the original PHIGS primitives and attributes. The PHIGS+ primitives use the attributes of the original PHIGS primitives for Polyline, Fill Area, and Fill Area Set. This preserves the original PHIGS model and promotes migration of applications using PHIGS to PHIGS+.

The higher-order primitives included in the PHIGS+ specification allow the parametric definition of curves and curved surfaces. The polynomial- and B-spline-based curve and surface primitives let applications most accurately approximate and render smooth shapes, such as pipes, car fenders, windshields, aircraft fuselages, wings, and smooth mechanical parts. The lighting and shading models combined with surface properties of polygonal and surface primitives allow the accurate simulation of illuminated objects by means of Gourand and Phong shading.

Designing a PHIGS Implementation

Designing a graphics system to operate efficiently in multiple computing and graphics environments requires the definition of a conceptual computer and conceptual graphics device. These principles have existed for several years; device-independent graphics software is not a new topic. However, the developers of earlier systems used an interfacing philosophy that usually pivoted around the least-common-denominator theory—that is, the definition of the software graphics device interface and software computer interface supported only those functions found on all systems to be supported. The rest of the required functions were performed in the device-independent kernel.

This philosophy worked well until graphics hardware became sophisticated and operating systems such as Unix and VMS could offload much of the work previously handled by the software product itself. Under the earlier philosophy, new high-performance graphics workstations would be treated as if they were film recorders connected to a large mainframe running a batch operating system.

Optimizing the interfaces between the major components of a computer- and device-independent graphics system requires that each subsystem understand the capabilities of the other to allow the migration of responsibility as a function of the capabilities of the graphics devices and the computing environment. In the graphics industry, this has been called "device intelligence." But the same philosophy and principles can apply to computing environments.

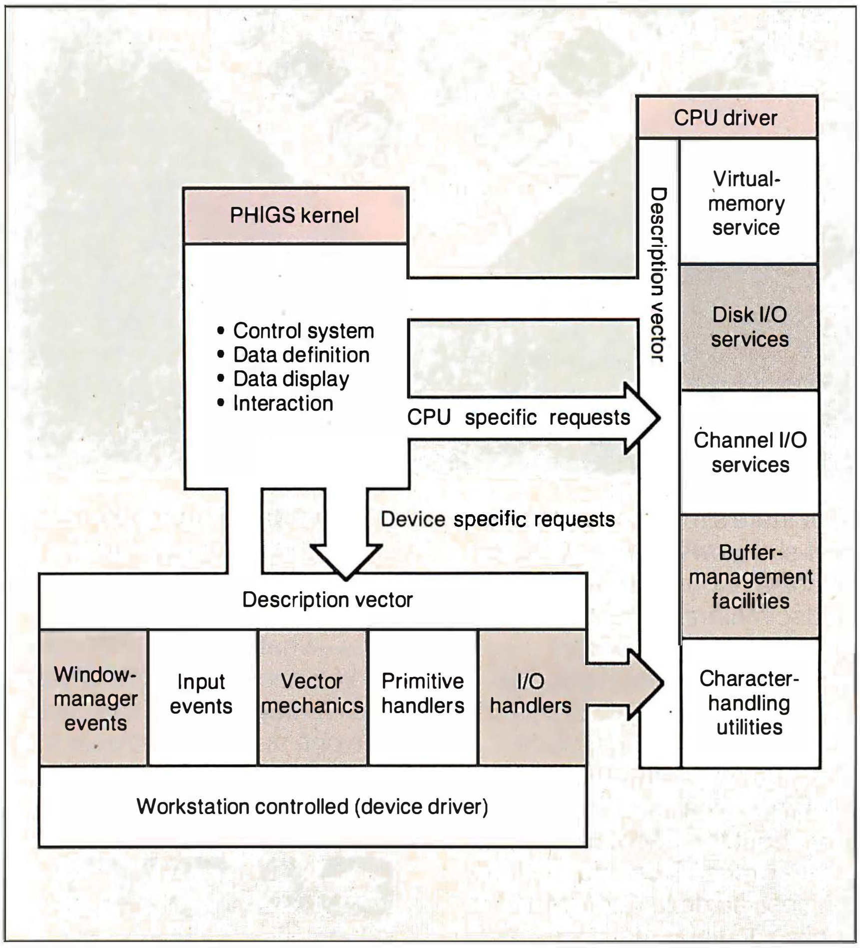


Figure 4: *Figaro's CPU and device intelligence.*

Figaro's Architecture

Template Graphics Software's Figaro, a PHIGS implementation based on this theory, consists of three different software modules: the PHIGS kernel, the CPU driver, and the graphics device driver, called the *workstation controller*. The design of this system employs both device intelligence and computer intelligence. To promote efficiency, Figaro's designers defined description vectors and communication protocols between these systems so that the division of labor during execution of an application could be adaptive (see figure 4).

A simple example of this is the use of virtual memory. Both VAX/VMS and Unix support run-time allocation of virtual memory. But IBM VM/CMS and MVS/TSO do not. Rather than develop two distinct implementations of Figaro, one for IBM and one for VMS and Unix, the designers incorporated both. By establishing internal logic within Figaro to manage its own paging system once virtual memory was exhausted, the same code could be used on both IBM-based and VAX- or Unix-based computers.

On IBM systems, virtual memory is

continued

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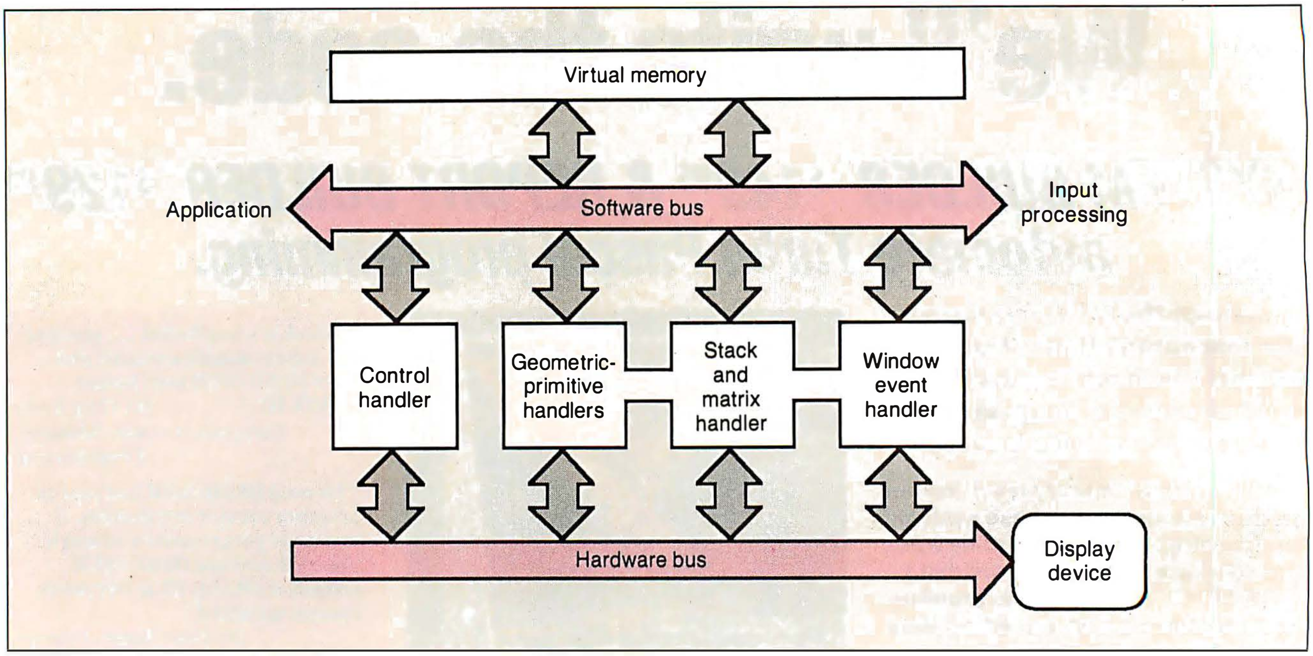


Figure 5: *Figaro's graphics engine interface.*

immediately exhausted because none can be allocated at run time; thus, Figaro would take over with its own paging system. On VMS and Unix systems, Figaro uses run-time allocation of virtual memory until it is denied access due to exceeding working size limits; it then rolls over into its own paging system using the existing allocated virtual memory as a cache.

Similar strategies are applied to optimizing disk and channel I/O. The computer-dependent subsystem has the internal knowledge of optimum buffer sizes and disk record sizes for the underlying operating system configuration. These are communicated to the Figaro kernel via description vectors. The kernel then has sufficient information to decide whether it should use the recommended parameters from the computer driver or override them.

Vector mathematics is another realm of optimization. Many of the new workstations have special functions used to multiply matrices. This can make significant differences in transformation, clipping, and rendering time of geometric primitives.

Graphics Engine Interface

These general principles were used to establish the Graphics Engine Interface (GEI). This interface is internal to Figaro and allows the flexible integration of a conformant PHIGS implementation with newly developed hardware, which may or may not be able to support all the PHIGS functionality in hardware directly.

The GEI establishes a multilevel graphics device interface for processing fundamental picture elements created during the traversal of the PHIGS CSS. Each picture element consists of a PHIGS or PHIGS+ geometric primitive, its respective current attributes, and the composite, modeling, viewing, projection, and workstation transformation matrix.

Through this interface, a designer can easily determine if the picture element can be processed directly by the underlying hardware or if intermediate logic is required so that interfacing at a lower level is possible (see figure 5). The GEI was used to develop high-performance interfaces to the graphics workstations manufactured by Silicon Graphics, Sun Microsystems, Hewlett-Packard, Prime Computer, NEC, and Stellar Computer.

Acceptance of PHIGS and Figaro

PHIGS is gaining momentum rapidly. Both the National Computer Graphics Association and the Association for Computing Machinery's Special Interest Group for Computer Graphics have sponsored tutorials at their respective national conventions to teach the concepts of PHIGS and promote graphics standards. Other technical committees such as the PHIGS+ and three-dimensional X Window System groups have compatibly expanded upon the foundation set by ANSI PHIGS.

Putting the theory of graphics standardization into practice requires industry commitment. Template Graphics Software began working on an implementation of PHIGS early in 1984. In 1985, TGS introduced Figaro, still the only commercially available implementation of the PHIGS proposed standard.

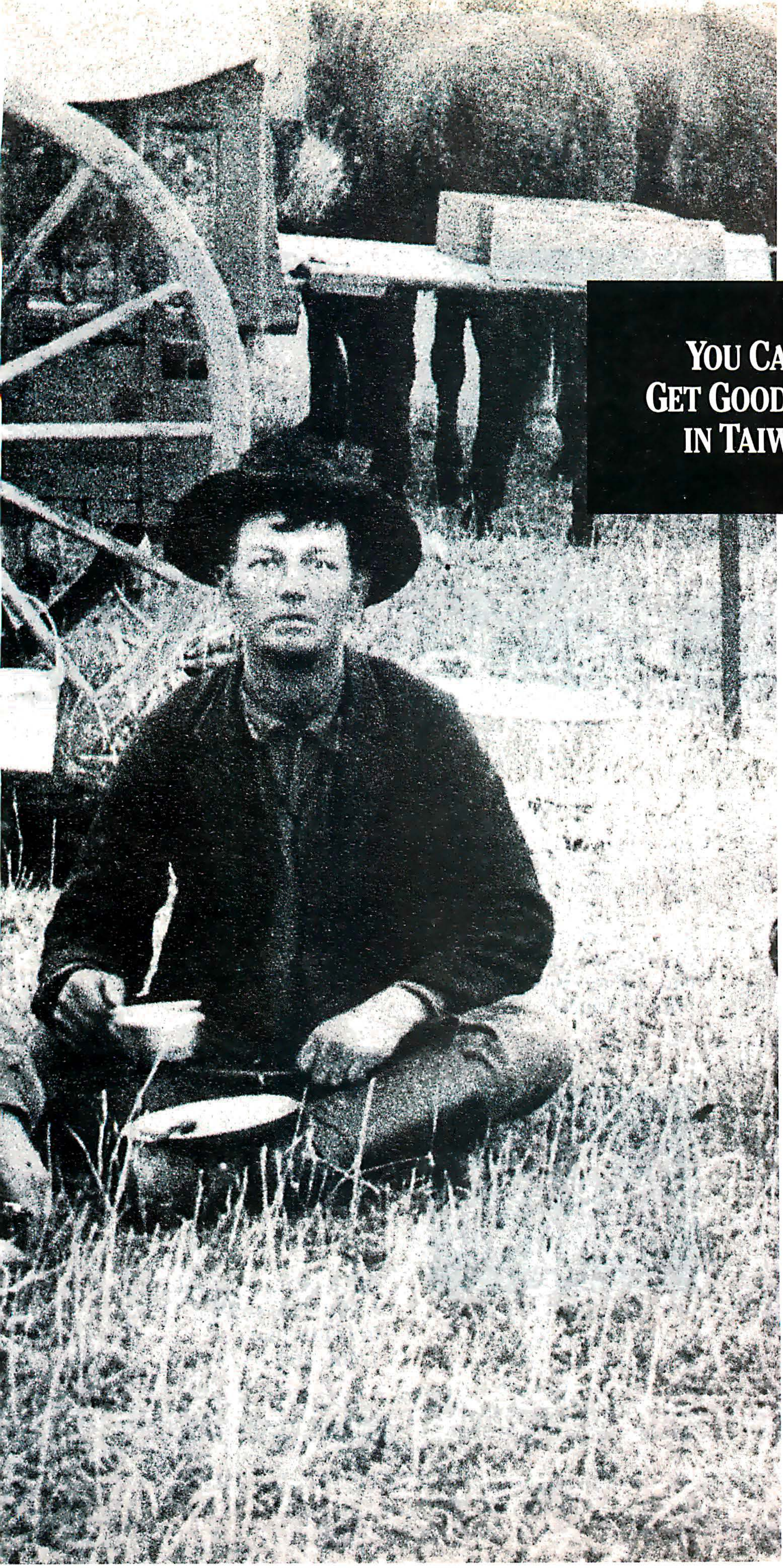
TGS has concentrated on satisfying the requirements of the top Fortune 100 companies requiring a three-dimensional graphics programming standard. These large corporations develop chemicals and build automobiles, aircraft, and power plants. They are changing their technological methodologies to use the new engineering workstations in addition to existing mainframe computers. The establishment, availability, and delivery of PHIGS, operating efficiently in both the workstation and mainframe environments, simplifies some of the complex issues facing these companies during this transition.

Figaro is now fully suppported on VAX/VMS, IBM VM/CMS, MVS/TSO, Apollo Aegis and many major Unix workstations, including Sun, Silicon Graphics, Hewlett-Packard, Masscomp, Prime, Convergent Technologies, CalComp/Sanders, Celerity, Motorola VME, and NEC. In addition to these workstations, Figaro also supports 200 graphics display devices, ranging from pen plotters, film recorders, and metafiles to interactive color terminals and monitors.

The cooperation between the hardware manufacturer and the software supplier will guarantee two critical components required to deliver a technology standard. First, it will ensure that product combinations function and perform to the expectations of current technology. Second, it will provide compatible product combinations on a variety of hardware platforms. ■



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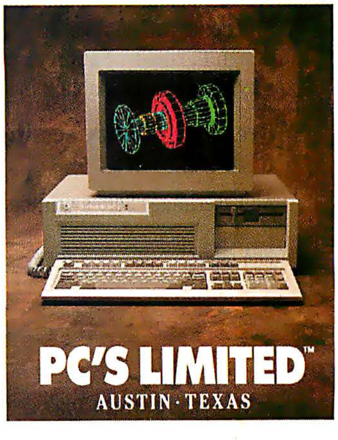
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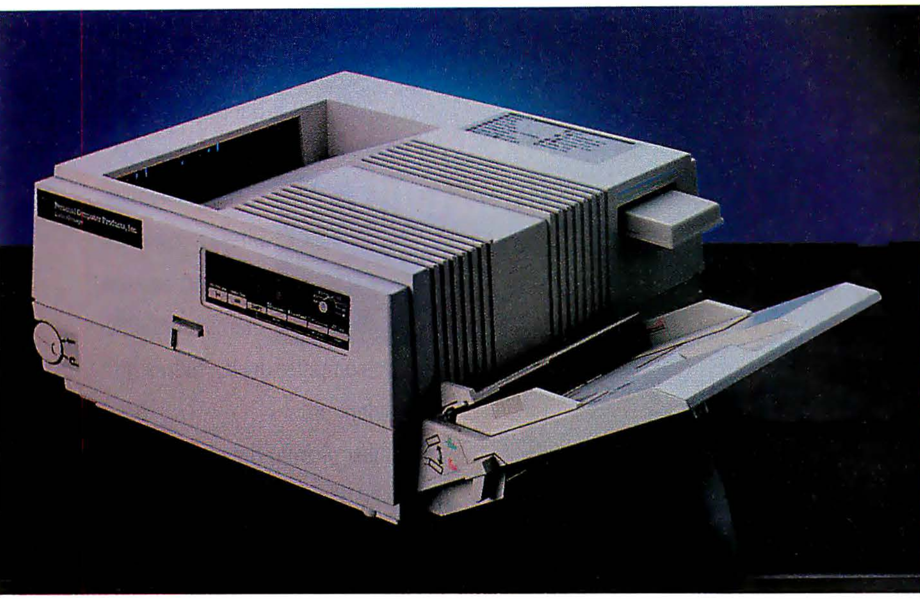
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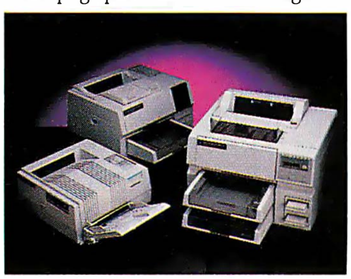
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Distributed Processing: The State of the Art

Two experimental distributed operating systems: Carnegie-Mellon's MACH and Stanford's V

W. Anthony Mason

COMPUTERS WERE ONCE scarce enough, and limited enough, that communication between them was impractical and unnecessary. As computers grew to multiuser systems, communication was limited to terminal/computer protocols, such as the RS-232C (serial) specification, which is still widely used. It isn't surprising that this available protocol was modified and used as the basis for intercomputer communications. Still, because of the scarcity of peer machines, the need for this type of communication was limited.

However, as the number of machines and users increased, the use and demand for communication increased. Unix, the premier multiuser system today, came with the simple yet effective UUCP (Unix-to-Unix copy). It took little to modify UUCP and its peer UUX (Unix-to-Unix execution) to allow for handling electronic mail. From humble beginnings, the number of machines using UUCP and exchanging mail and other electronic communications has mushroomed, as anyone who has read Usenet (the ubiquitous international Unix bulletin board system), can tell you.

As multiple-machine environments became more prevalent, the demands on UUCP transfers became a significant burden. Through the ingenious use of hardware and software, both local and wide area networks were developed for higher-speed data communications. In the Unix world, Ethernet and TCP/IP (Transmission Control Protocol/Internet Protocol) became the predominant standard. Because of the greatly improved speed of intermachine links, and the higher power of the machines being linked, new uses were created for those links, such as the Telenet protocol (which allows remote log-ins), and the remote execution protocols.

The Unix kernel size exploded with the increase in software necessary to process this additional overhead. From the PDP-11 days, when the Unix kernel fit in very memory limited machines, to today, when a BSD (Berkeley software distribution of Unix) 4.3 kernel absorbs 4 megabytes on a VAX 8350, the area of greatest growth has been networking.

Additionally, the cost of this explosion in software size was a loss of the elegant Unix view of all things as files. Instead, we now have files, sockets, semaphores, message queues, streams, and even more specialized data types.

The Diskless Workstation

This new, high-speed networking capability, coupled with a dramatic drop in the cost of CPU resources, encouraged the current proliferation of diskless workstations. In principle, because a high-powered CPU is inexpensive, and disk resources have a high initial cost, it makes good sense to centralize disk resources (one large disk is not much more expensive than one small disk) and decentralize CPU resources. In fact, by investing in high-speed, high-reliability drives, as well as drive technology, the communications overhead of using the network for file serving is negligible.

However, prior to the decentralization of CPU resources, the system response time for a given individual was typical of the response time for any other individual. When the machine was only lightly loaded, response time for everyone would be good. With workstations, it is possible that a particular user can have a significantly slower response than someone else using the same disk resources. Thus, the "equality of response" has been traded for lower cost and higher performance.

Distributed Operating Systems

Two factors are leading the way into the new area of distributed operating systems: a skewed utilization of resources, which adversely affects users, and the loss of simplicity in kernel construction, which adversely affects system software designers and, ultimately, hardware manufacturers.

One method used in stand-alone machines to obtain better performance is to increase the number of processors. The so-called parallel-architecture computers are the extreme example of this method. Their development has been useful to the cause of distributed operating systems, because many of the basic abstractions used in these parallel machines can also be used for distributed operating systems.

Message Passing

The two primary methods used for interprocessor communications are message

continued

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passing, used in loosely coupled systems, and memory sharing, used in tightly coupled systems.

Message passing consists of a mutually agreeable protocol between the CPUs (or processes in a distributed operating system) and the messages. Messages from one CPU to another are then exchanged (the CPUs could be either in a single parallel machine or a distributed system). This illustrates one of the strong similarities between the parallel-architecture communications process and distributed processing.

Because of the uncertainty associated with network communications, it is the duty of both machines to confirm the integrity of the communications link. Thus, the protocol typically incorporates an error-detection method. It must also specify how to initiate and terminate the communications channel. As it is possible that more than one channel may be open at a time, some form of message differentiation must also be incorporated.

In addition, in an open network, there must be some system of message validation to provide a level of security. Without it, a remote workstation could make a potentially harmful request. Despite these requirements, the actual message header must be small to minimize the chance for corruption and allow for rapid processing. This also keeps the message cost low (if the message must be retransmitted).

Shared Memory

Shared memory, in contrast to the message-passing scheme, consists of a common area where any of the CPUs can read or write. Because of the potential for synchronization errors, there must be an access control mechanism so that the recipient CPU cannot read before the sending CPU has sent its message, and so that the sending CPU does not write until the recipient has read the last information written. If the shared memory is considered unreliable, error detection must also be incorporated into the memory itself.

Thus, message passing and shared memory accomplish the same thing through different methods. Message passing is more difficult to deal with conceptually than shared memory. A variable can "point" into a shared-memory region, but the same analogy cannot apply to a message. However, shared memory does not exist between independent (uncoupled) CPUs. Thus, it provides a convenient view for the programmer, while message passing provides a more flexible model in a mixed-machine environment.

MACH and V

There are specific functions that any operating system must perform. It must manage machine-specific resources, such as disk drives and controllers, video controllers, multiplexers, and network hardware. It must also provide memory management, scheduling for resource-sharing among programs, and a uniform and convenient access to system services for applications programs.

In addition, a distributed operating system must present a uniform interface across all machines in the group, provide for kernel-level communications, and provide a transparent programming interface. It is becoming more important that an operating system provide tools for distributed programming.

Carnegie-Mellon University's MACH and Stanford University's V are two experimental distributed operating systems. Both MACH and V provide all the tools of an operating system and a distributed operating system. Many of the tools are similar, albeit with different names, but MACH and V each have unique advantages and disadvantages. It is useful to examine both systems because they reflect the direction that future operating systems will take.

Tasks and Threads

In terms of the above requirements, MACH uses several basic abstractions. First, the *task* is the basic unit of a resource, or *execution environment*. For example, the memory management could be thought of as controlling the resource of memory, and would thus be a task. An individual flow of control within that task, which MACH calls a *thread*, would have its own private *processor state* (e.g., machine registers), and a thread running within a task would then be a *process*.

The usefulness of this abstraction is that by dividing the machine state (thread) from the process, it is now possible to have multiple threads per task (for a machine with tightly coupled CPUs, this would work

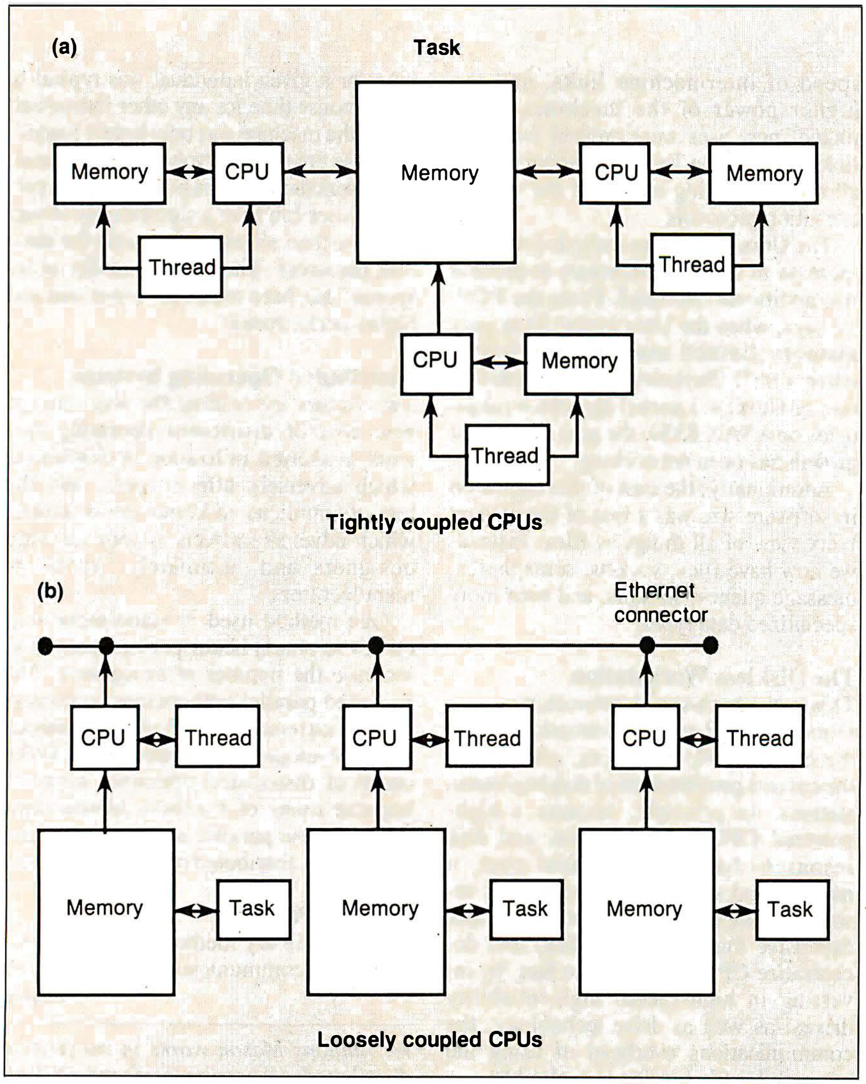


Figure 1: *The relationship of tasks, threads, and CPU configurations.*

well). Thus, the MACH kernel provides mechanisms for creation and control of tasks and threads (see figure 1).

In both theory and practice, it is relatively costly to establish a task (which corresponds to allocating a program address space and loading the program) but extremely inexpensive to establish a thread (which corresponds to saving a program's register frame). So, what is typical in MACH is to have few tasks but many threads within those tasks. With this understanding, optimization can be concentrated on thread creation and destruction, rather than on the (less productive and more difficult) optimization of task creation and destruction.

Ports and Messages

MACH provides for communications through a *port*, which is a message queue provided by the kernel. A *message* is a data object, or collection of data objects, used by threads to communicate. By providing ports and messages, any other object can be thought of as a port, and a request can be thought of as a message. Thus, the more traditional function-call model is replaced by a model of sending messages to a specific port. When MACH creates a task or a thread, it creates a port, owned by the associated task or thread, which provides an immediately obvious mechanism through which MACH then lets other tasks or threads manipulate it (see figure 2).

Under this model, the MACH kernel is essentially a server implementing threads and tasks transparently using the communications protocol. A thread cannot distinguish itself from another thread in the same task or a task running on a different machine. Equally, it could request a suspension on a remote thread just as easily as a local thread. By letting every thread be transparently equivalent, you overcome a major hurdle in the distributed systems game—namely, how to allow remote programs access to local resources, most notably the screen and keyboard. Since every thread *appears* equal to every other, the necessary transparency has been achieved.

The thread and task configuration lets MACH work with a variety of individual architectures, such as tightly coupled multiprocessor machines like the multiprocessor VAXes and the Encore Multimax. This type of machine uses a single task with multiple threads, the task existing in the machine's shared-memory space, and the threads corresponding to the individual processors.

MACH also works well with machines that use many closely linked tasks, such as the BBN Butterfly and the IBM RP3

continued

(differential-access shared-memory machines). Finally, MACH works with truly distinct nodes on a network, such as Sun or MicroVAX workstations, where there are many nonrelated tasks running on separate CPUs and using network communications.

Figure 3 is an example of a nodal layout (based on the layout of the distributed environment used at the University of Chicago). It consists of a trunk line that connects one end to the outside world, to other nodes at the other end, and to the physical nodes of the department between. The distinction of placing CPUs above or below the line is to establish the type of computers they are; the VAX-11/750 and the Pyramid 90X are both minicomputers. The three nodes on the lower edge represent three Sun file servers. Two of these have clients that they serve.

Although the clients are represented as connections from the file server, they are actually nodes on the network that use the services supplied by the servers. The third file server is an experimental machine that has no clients. It is used for experimenting with hardware and software and has a connection to Purdue University. This is an ideal distributed environment where both MACH and V would work well.

MACH's Virtual Memory Scheme

As operating systems have grown, the amount of available memory on machines has tended to increase. Commensurately, programs have increased in size and complexity. MACH's virtual memory system, although relatively straightforward, does illustrate the state of the art. MACH provides methods for allocation/deallocation of virtual memory and allows for protection and inheritance of virtual memory areas, referred to as *regions*. Additionally, a region can be set up as a copy-on-write region—an area that, when written to, is copied from somewhere else. This is especially useful in the Unix `fork` call, which copies the address space of the parental program.

Often, however, these forks are immediately followed by an `exec` call, completely overlaying the current address space with a new program. Because of the high overhead of copying one region of memory to another, as when creating a new task, copy-on-write is an optimization; the copying action does not occur until there is an actual attempt to change the address space. Those programs that load a new program save the overhead of copying, while those programs that wish to create a duplicate image can do so.

MACH allocates virtual memory in blocks referred to as *pages*. Each page has associated with it a protection level and an inheritance level. The protection level consists of a current value and a maximum value. The maximum value is the highest level of access that can be granted to that particular page. This value can be decreased, but never raised. The current value is the access allowed at that time. It is limited to being less than, or equal to, the maximum value.

Through this protection scheme, it is feasible to allow access to a region in shared memory between two or more processes. The inheritance level sets the access for child processes; the protection level controls the access for peer processes.

Inheritance levels consist of read/write access (shared), copy access, or no access. Read/write access is an area of shared memory between the parent and child processes that can be used by either. Copy access copies the region of memory into the child space, often using the copy-on-write facility for efficiency. When no access is allowed, that area is not part of the child-process address space. These protection schemes allow for sophisticated control over memory, which is useful when working across a broad range of architectures, making MACH easier to port and more flexible for the software designer.

In addition to access control, MACH provides page-fault control and page-out control. By further dividing the memory management tasks into machine-independent and machine-dependent areas, MACH can construct a memory management system independent of underlying architectural dependencies, such as machine page size. This differentiation also makes MACH more portable, an issue of significant concern as the number and range of machines continue to expand.

Uniform Access Interface

To use these services offered by the kernel, Carnegie-Mellon has developed a uniform

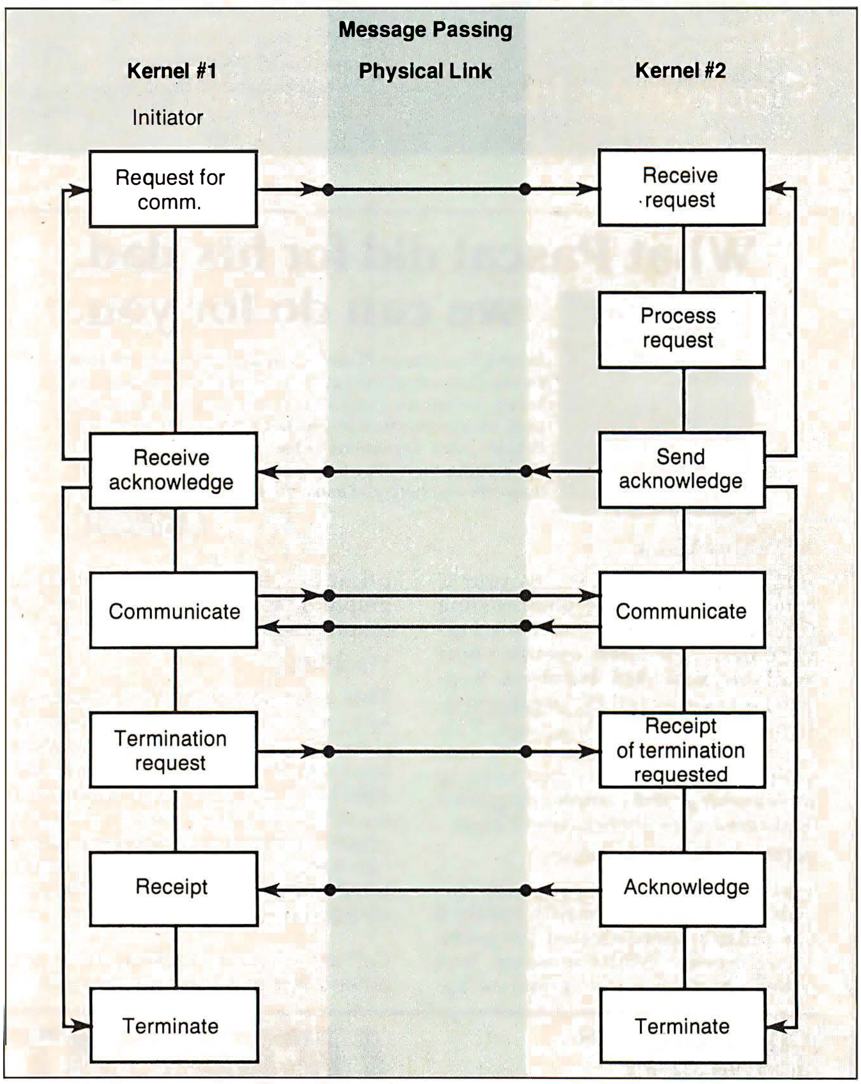


Figure 2: *A model of the flow of the message-passing process.*

interface for access that can be used from several high-level languages. Because of the communications-oriented nature of MACH, these interfaces consist of a library of "stubs," or routines that accomplish their tasks by communication with the appropriate kernel routine or server.

For example, a Unix-style I/O call such as `read` would be translated into an appropriately formatted request, packaged into a message, and then sent to the appropriate communications channel. This allows great flexibility, as that request can then be processed by the kernel itself or by another process. In fact, the request may not even be processed on the machine where it originated. Therefore, to the applications program, this entire level of communication is transparent. This is especially significant with a homogenous environment of clients with and without local disk drives. By setting up a remote file server (such as what exists in MACH), disk requests, paging, and virtual memory management can all occur using the network communications protocol.

Operating System Goals

Although V and MACH are considered distributed operating systems, their goals are quite different. MACH is an attempt to prove that the Unix kernel can be completely rebuilt to use the concepts developed by the Carnegie-Mellon team, without loss of functionality or of Unix's trademark—portability. On the other hand, V is an experimental system that, rather than profess complete Unix compatibility, serves as a tool for exploring issues in distributed operating systems.

However, it would be incorrect to say that V isn't usable. In fact, V is used at Stanford on a day-to-day basis. Figure 3 is an example of a distributed system environment that would benefit from using either MACH or V.

The V system approaches many of the more common operating system-related problems in much the same way as MACH, but in some areas it is unique, and it is these areas of divergence that lend insight into potential future directions of distributed operating systems.

Architecture of V

A major focus in V is not only an abstract division of responsibilities in the kernel, but a real, process-type division of effort. The kernel consists primarily of code that handles the communications. The kernel handles no disk access, no display access (aside from simple console communications), and no memory management. These functions are relegated to servers—independent processes that run in memory but use the communications the kernel provides to interact with both kernel and peer processes. Many of the V abstractions center around this decentralized view of control.

Specifically, the view of the V kernel is as a bus system with slots and objects in those slots, such as a peripheral card (see figure 4). The kernel serves as the bus, the primary controller of the interaction between individual slots and between slots and the outside world. By extending this view, we can think of every independent node as part of the bus, and the individual process running on a node as an independent slot. Thus, any slot is addressable from any location on the bus, leading to a transparent multinode environment.

The V kernel is the only process that "realizes" in any sense that there are other processes running on the machine. Thus, on every machine, the kernel has two layers: a uniform layer it presents to the rest of the world (its connection to other segments of the bus) and a machine-specific layer that optimizes kernel-level performance on that particular machine. The first layer must be uniform across all machines. The current implementation of V, running on both Suns and VAXes, accomplishes precisely this task.

Realization that processes are either "local" or "foreign" occurs only at the machine-specific layer. When two local processes communicate, it is grossly inefficient, albeit consistent, if the kernel packages the request and broadcasts it; then receives it, unpacks it, and hands the request to the second local process. Rather it is at this level, and only this level, that the kernel traps such requests and short-circuits the normal interprocess communications method. By prohibiting any other process from doing this, it simplifies the task of making the kernel secure (requests must pass through the kernel, be authenticated, and then handed off) and of making sure the kernel functions correctly.

Interprocess Communications

These servers perform functions necessary for any operating system. There are currently kernel servers for time and process management and scheduling, memory management, and device management. All these services are accessed through the interprocess communications mechanism rather than the more tradi-

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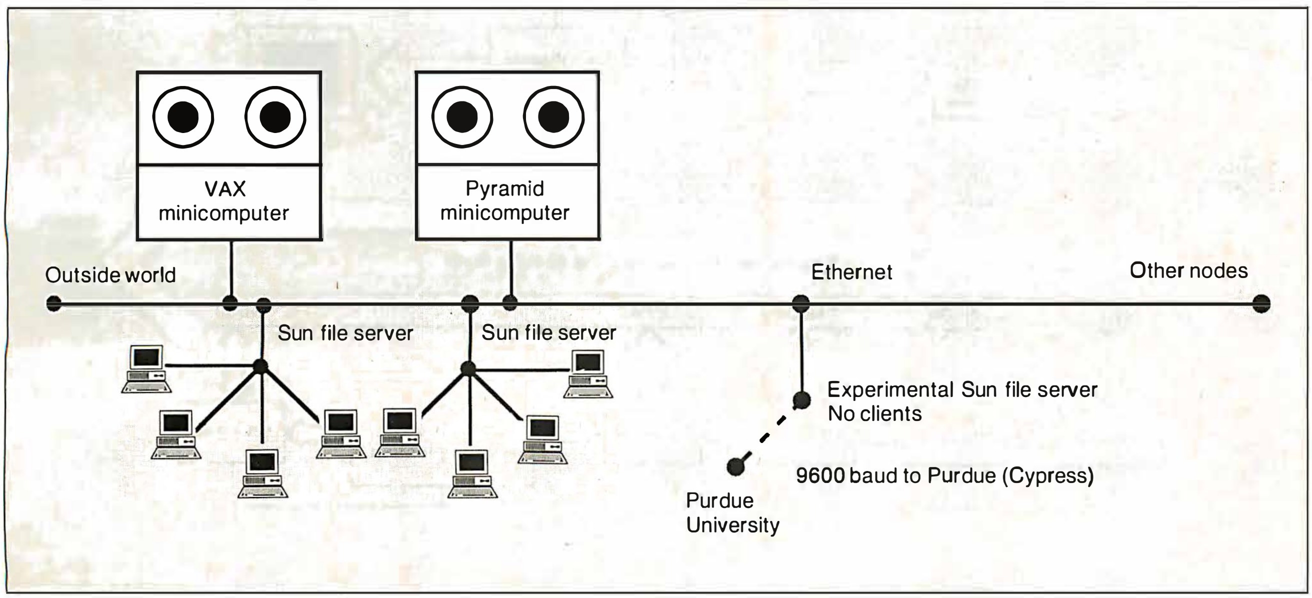


Figure 3: *The distributed processing environment used at the University of Chicago.*

tional method of direct function-call access.

This division of labor has two significant advantages: First, it greatly simplifies the debugging phase of building the kernel, as the individual servers are significantly smaller alone than the kernel would be if all services were provided directly by the kernel. Second, because V is used as a research environment, it allows for rapid change within the kernel and servers while not affecting the manner in which the kernel and servers interact. By cutting down on potential side effects, V illustrates the tendency toward increased compartmentalization of functionality.

Multicasting

Using the bus/slot idea, V has added a multicasting capability to the normal interprocess communications protocol. By taking related processes (a group), a transmission can be sent to the entire group and action taken by the appropriate process. One of the more useful purposes for which this has been employed is load scheduling—running a process on the CPU with the lowest load.

Thus, rather than broadcasting 25 individual packets to 25 machines on the network, it suffices to multicast 1 packet. Although 25 packets will still be returned, you have used the network to broadcast 26 packets instead of 50. This use of process grouping and multicasting has been so successful that, in the future, it is likely V will support more group process commands (which allow control of an entire group of processes rather than requiring the high overhead of broadcasting a request to each individual process).

Critical Issues

With the typically high number of nodes on a workstation-based environment, it becomes increasingly necessary to let the segmented bus design be not only transparent, but also resistant to a particular node disappearing (caused by a power failure or a system crash).

This becomes critical to workstations that have no disk servers themselves but rather are served by other nodes. To further complicate this task, it is possible that the services offered by the file server nodes will not be uniform. There is no requirement that services be uniform, only an insistence that they be uniform in terms of access. To present these potentially different services in a manner that the client can dynamically deal with is both difficult and critical for solid operation.

V uses a block-oriented data model instead of the more traditional byte-oriented Unix model. This fits in well with an interprocess communications–based system, as most data is transferred in blocks. Additionally, the block model fits in well with typical semantic units, such as database records.

Also, in contrast to Sun's Network File System, V uses a stateful, rather than stateless, file system. Thus, prior to many operations, other initialization operations must be performed. This works well on a system where a resource may disappear at any time.

Finally, V provides a variety of access types, referred to as *compulsory*, *optional*, and *exceptional*. These types correspond roughly to sequentially accessed streams, primarily sequential streams with some special access features, and full-scale random access files, respectively.

This broad-scale view of I/O can be used to implement more traditional services, such as pipes, files, displays, printers, and internet protocols. In fact, V uses this mechanism to track currently executing programs. This is a nonobvious usage, but one that illustrates the power of this method of viewing I/O. Despite the complexity this model introduces to the functions that the operating system must provide, the overhead is not visible to the application-level program, as the run-time libraries handle the overhead associated with this conversion. What it does provide to the applications program is durability—the ability to work even in an unstable environment.

Using the services provided at the kernel level and through the servers, V provides a transparent mechanism for working in a multiple-machine environment. Currently, V is being ported to an experimental DEC processor known as the Firefly, and an experimental shared-memory multiprocessor from Stanford known as the VMP. Thus, V appears to be growing from the distributed workstation environment toward the multiprocessor machine environment.

continued

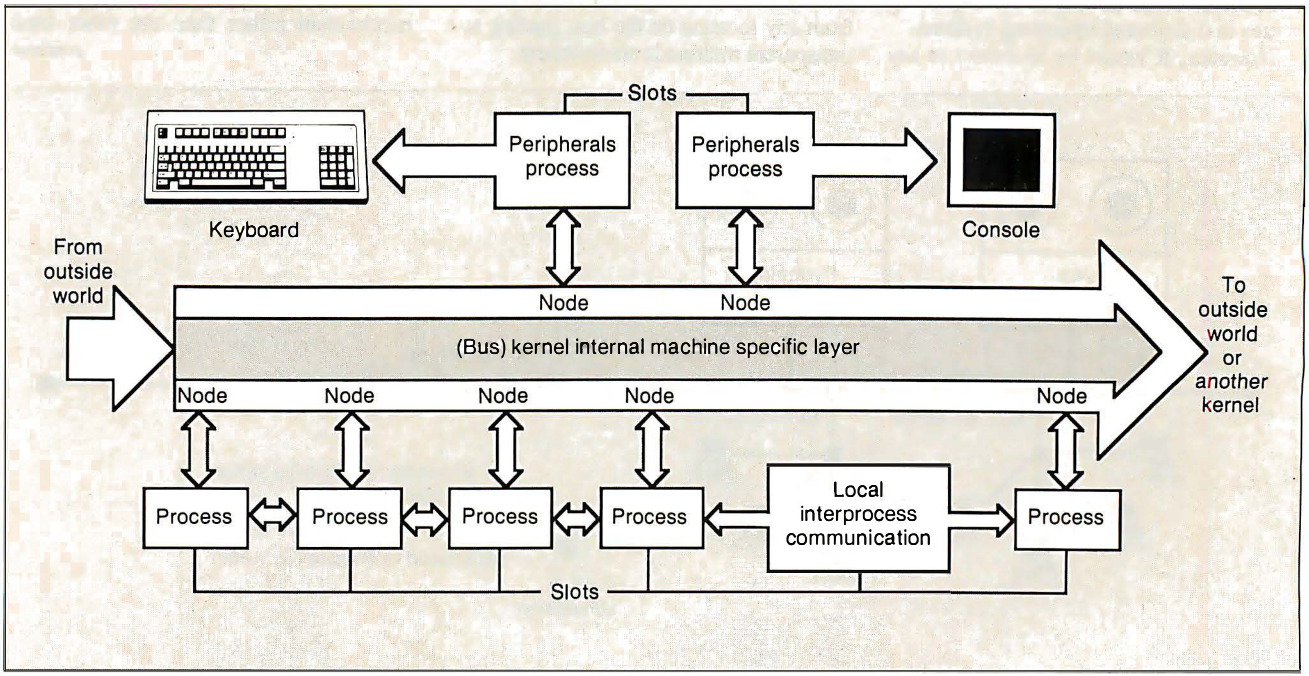


Figure 4: *A block diagram of the architecture of the V operating system.*

The V model has also been used in parallel computation across machines, and additional work continues exploring the problems and issues involved in parallel (and hence distributed) programming. Currently, additional work is being performed in increasing network speed and lowering network overhead, but more understanding of the issues involved in parallel languages and parallel systems will also be required.

Common Denominators

MACH and V perform all the functions of a standard operating system and expand this functionality across a network of single- and multiple-CPU machines. Both tend toward decentralization of the kernel, dividing it into service routines and, eventually, into independent servers. The critical element that both systems rely on is the communications facilities available to the network.

Traditionally, operating systems have provided disk I/O and device control as their primary services, but networking has changed that significantly. The forefront of research reflects the realization of this change. The emphasis in the design of the kernel was on those machine-dependent facilities for two reasons: First, those facilities need to be buffered from the applications programs that require them, so that the programs can be independent of the hardware on which they run. Second, those facilities, because they are used extensively, must be optimized and built to take advantage of any speed increases available.

Future Directions

Computers have changed dramatically. Today's computers bear little resemblance to the minicomputers of the 1970s. Where those machines required optimization in areas of memory management, disk I/O control, and terminal I/O, today's machines require optimization in network access and use. Although the machine-dependent nature of these functions has not disappeared, the requirements that they be tailored to individual hardware has been superseded by hardware design and improvements that make such considerations unimportant.

Both MACH and V are written primarily in C, a trend that started with Unix and is common today. In the early years, it would have been unacceptable to write operating systems in a high-level language—with the associated high overhead cost—rather than assembly language.

Today, operating systems run on machines that are sophisticated enough and fast enough that this overhead is negligible, especially when compared to the cost of developing the operating system. This trend is likely to continue. It leads to operating systems that are easier to design, maintain, and port to new architectures.

MACH and V both implement extensible software systems from which even newer, more advanced operating systems can be developed. The movement afoot is to improve this abstraction by refining interkernel protocols, such as Stanford's VMTP. Additionally, extending the operating systems to work on a wide variety of architectures gives users a choice of what areas they want to optimize without losing the potential for future expansion or working with the equipment and machines of the past.

MACH and V accomplish this by providing mechanisms that should work for the near future with new architectures. Both MACH and V work with Unix—MACH through direct compatibility on a source and binary level, V through a V server that runs on Unix machines and lets V workstations access and use Unix file structures. Thus, either can be integrated into an existing Unix environment without loss of valuable software and familiarity.

Because of the strong similarities between parallel architectures and distributed architectures, both can be used for additional development in parallel programming. The notion of nodal instability, which comes from networked machines (any machine may disappear), can be used for fault-tolerant systems. Exploring issues in distributed operating systems illuminates new areas in distributed programming. Finally, by using distributed operating systems, an unused workstation sitting on a desk in a locked room suddenly becomes available.

This, more than anything, will be a very attractive advantage to sites using many small, high-powered personal workstations. Improving workstation utilization will make workstations more popular and more cost-effective. Once the workstations are actually in use, the additional benefits of fault-tolerance, parallel processing, and parallel programming will become more important.

Computers have evolved from monoliths to desktop powerhouses. As more has been offered to the computer user, more has been asked for. Distributed operating systems are another step up the ladder. ■

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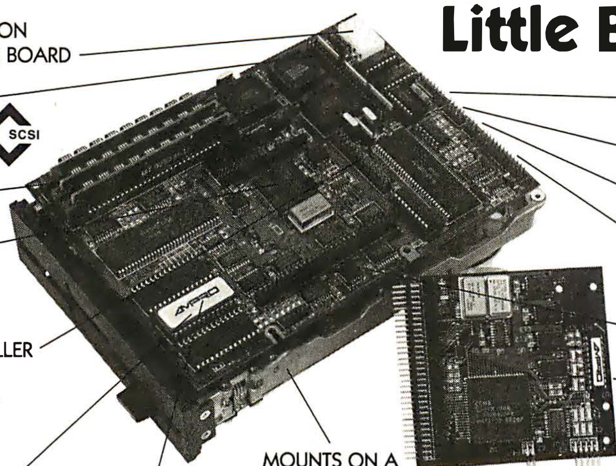
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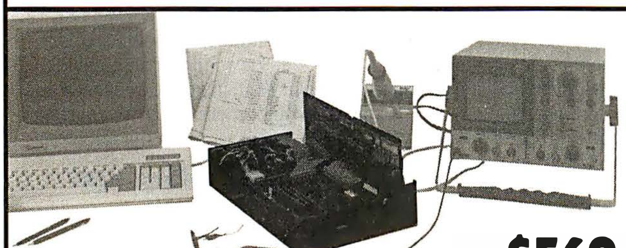
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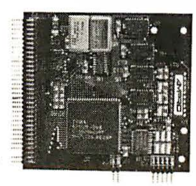




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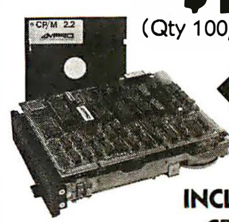
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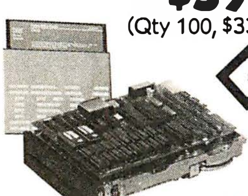
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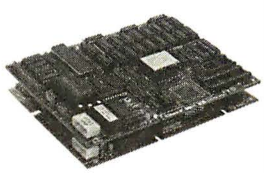
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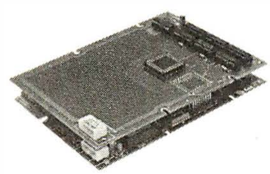
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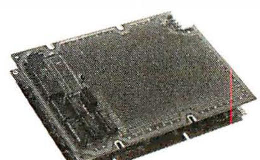
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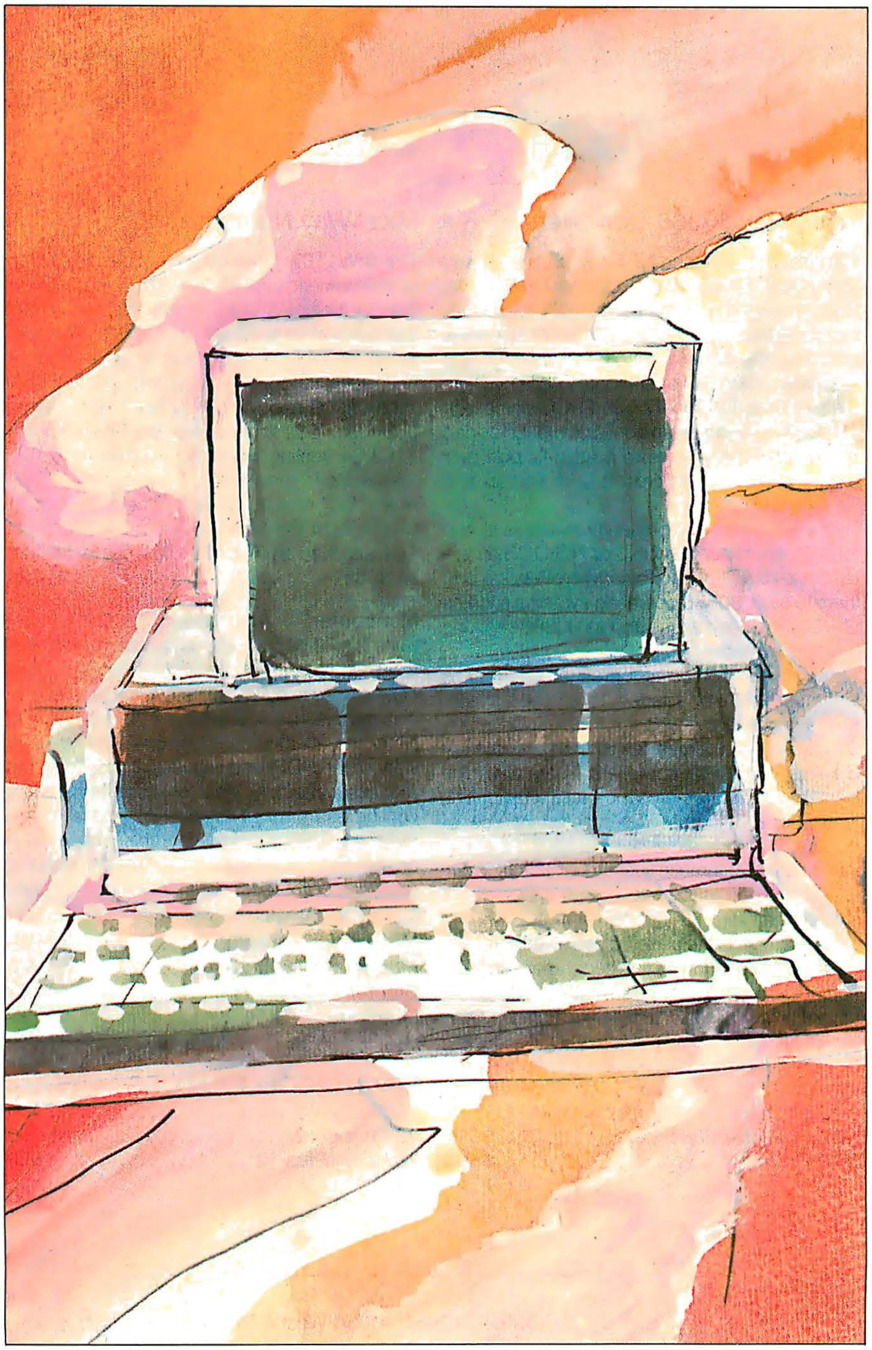
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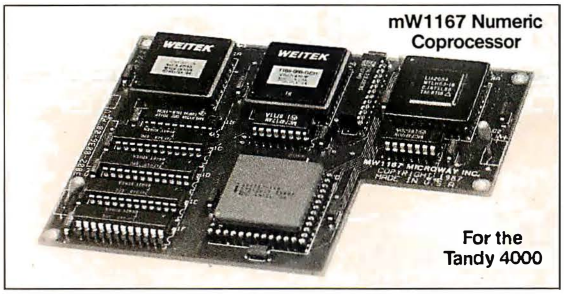
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The compilers are presently available in two formats: Microport Unix 5.3 or MS-DOS as extended by the Phar Lap Tools. MicroWay will port them to other 80386 operating systems such as OS/2 as the need arises and as 80386 versions become available.

The key to addressing more than 640 kbytes is the use of 32-bit integers to address arrays. NDP Fortran-386 generates 32-bit code which executes 3 to 8 times faster than the current generation of 16-bit compilers. There are three elements each of which contributes a factor of 2 to this speed increase: very efficient use of 80386 registers to store 32-bit entities, the use of inline 32-bit arithmetic instead of library calls, and a doubling in the effective utilization of the system data bus.

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Part 1: Hardware

Steve Ciarcia

Build the Circuit Cellar IC Tester

This versatile tester can save you hours of troubleshooting when building and debugging electronic systems



Having designed and debugged many electronic systems, I have seen more than my share of defective ICs. I have also wasted more time than I care to remember discovering that my latest creation was not deficient, but that one of the factory-fresh ICs I put in it was in fact defective. You'd think they'd test them, wouldn't you?

An IC tester can provide both time savings and increased confidence when building and debugging electronic systems. In fact, finding defective ICs before manufacturing an electronic product can also save a considerable amount of money by minimizing the labor and board damage costs involved with reworking electronic boards.

For the most part though, IC testers are used for repairing failed electronic circuits. My latest example was my home: While I was preparing this project, lightning struck my house and practically everything got blitzed. If it were not for my IC tester's help in finding the 29 blown chips in my home-control and automatic-lighting system, I'd still be sitting in a dark, dead house (I thought I had added every preventive measure I could, but I can see we'll need another project on transient protection). I was especially thankful that it could successfully test open-collector driver chips—a problem for most economical testers.

Having an IC tester saved my day, and it may be something you have always needed, too. This month, I will describe the design and construction of a digital IC tester with tutorial emphasis on the thinking I had to go through in the process of building it. I will conclude it next month with a discussion of the specific operation of this tester and its advanced software.

Design Considerations

The first step in designing any project is to carefully consider and define what the device is to do. For the IC tester, I first looked at units already on the market and noted their features, prices, deficiencies, and benefits.

I found a price range that varies from less than $200 to several thousand dollars. They also vary considerably in their operation and capability. The low-cost units are generally bus-specific—plugged into a computer slot (Apple II or Commodore 64)—and include operating software. Up the scale from those are the stand-alone—but relatively "dumb"—IC identifiers. With these, if you put a good chip into the socket, a two-, three-, or four-digit number indicating its identification appears on the seven-segment LED display.

The low-end (less than $1000) testers I found have fixed device libraries and perform only simple digital tests (i.e., no AC-parametric tests and no logic-threshold tests). Most, however, indicate that they do provide "periodic" library updates as new standard parts become available.

The high-end testers, costing several thousand dollars, allow some AC-parametric testing, threshold testing, and testing of analog ICs. While they are probably incapable of verifying complete compliance to manufacturers' data sheets, they certainly come close. They can help identify chips with marginal timing specifications. The cost of these devices (including the cost of maintenance, special adapters, and new device support) makes them prohibitive to ordinary users; such devices typically find their home in large corporations with special testing requirements (often those involved with military or aerospace applications).

Flexibility at an Economical Price

My goal in developing the IC tester was to provide as much capability and flexibility as possible in an affordable device that can be used by small businesses and electronic experimenters.

Certainly, economics played its part in requiring compromises in the design. I decided that AC-parametric testing and threshold-level testing would put the device into a higher-price category than I was targeting, so these features were the first to go. Then, I needed to determine what the user interface should be like.

One possibility was to design a card that plugged into an IBM PC slot, with an external test box connected by a cable. This approach would let me develop and include PC software permit-

continued

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. The author of several books on electronics, he can be reached at P.O. Box 582, Glastonbury, CT 06033, or on BIX as "sciarcia."

ting users to develop tests for their own devices. This would include standard devices not yet in the master library and custom devices, like programmable array logics. Unfortunately, this limited the use of the tester to owners of PCs or compatibles (with a free backplane slot and a long extension cord), and the tester would hardly be portable.

Another possibility was to configure the tester to connect to a dumb terminal, or to any computer with terminal-emulation capability, via RS-232C. While this would broaden the number of potential users of the tester, and would give the tester a little more flexibility, it would also take away the flexibility of user-generated device tests unless that extra (and I might add, very intensive) software capability was provided within the tester.

Finally, I could choose the pure stand-alone approach. Such a configuration would be a self-contained portable tester with its own display and some form of entry panel. Even though it's an easier concept, a stand-alone unit would be more expensive to build and would potentially have the same limitations as terminal-based testers unless it also contained the "smarts" of a larger computer.

Three Units in One

After considering the various circuit possibilities, I concluded that my IC tester should support all three modes of operation. With only a slight increase in hardware complexity, I could present a single design that operates in different ways depending upon which peripheral components and software you install (see photo 1). The operating configurations are called PC-host mode, terminal mode, and stand-alone LCD mode.

The PC-host and terminal modes simply require a serial port for operation. In terminal mode, the tester presents all statements regarding test functions and results on the video terminal's display. The PC-host mode is similar, with the exception that it has the added flexibility of letting you directly modify and extend the device library.

In the stand-alone LCD mode, the tester shows device parameters and data on a 2-line by 20-character LCD. (It should be noted that the LCD is optional; you can operate the tester in the other two modes without it.)

In essence, the stand-alone LCD mode provides a portable (i.e., battery-operated) IC tester suitable for testing any chips that are precoded within its extensive EPROM-resident device library. (The Revision 1.0 library currently contains about 600 74xx00-series and CMOS 4000-series chips.)

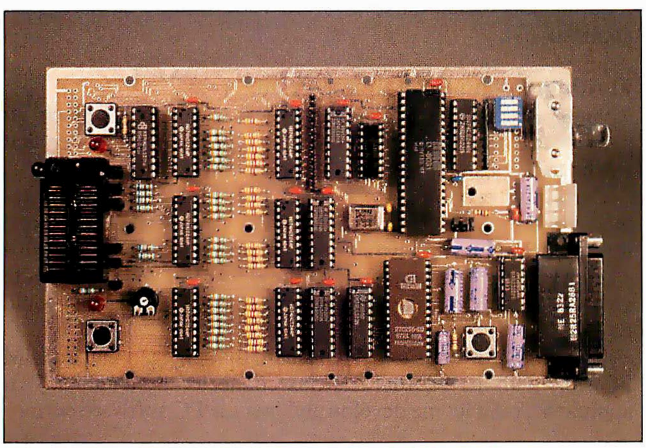


Photo 1: *The prototype IC tester printed circuit board configured for terminal operation. The IC under test is inserted into a special zero-insertion-force socket on the left side, and test information and menu selections are displayed on a terminal connected through the DB-25 connector on the right side.*

The terminal mode provides a menu format intended to maximize the information displayed, while the PC-host mode converts this otherwise stand-alone piece of hardware into an interactive and configurable diagnostic tool with the intelligence of a full computer.

Testing Logic ICs

How do you go about testing ICs? Certainly, I had to answer this question before I could design the tester.

Testing 7400-series logic devices appears relatively straightforward (I didn't consider AC and voltage threshold checking for reasons of economics). To test a two-input NAND gate, for example, you merely set specific logic levels on the gate inputs and check that the outputs are what they are supposed to be.

The process involves a series of test vectors. A test vector is a pattern of bits (0s and 1s) applied to the inputs of the device under test (DUT), to which the DUT responds with a response vector (a pattern of bits on the DUT's outputs). You then compare the response vector from the DUT to the expected response vector, with bit differences indicating pin failures.

You can specify any number of test vectors for a device, allowing you to test the chip as completely as you desire. For each test vector specified for a device, you must also specify a corresponding expected response vector. Since there are cases when some outputs of a device may be in an unknown state, you must also provide a "don't care" mask for each expected response vector, indicating which bit comparisons the tester should ignore.

One significant difference between my IC tester and others in the same price range is that mine does a full-function logic test using as many vectors as necessary to exercise all logic possibilities on the test device. Most inexpensive testers don't do this.

So Many Logic Families

Unfortunately, real-world electronics doesn't quite follow theory. Specifying test vectors is only part of the job. Dealing with all the electrical parameters of the various IC logic families is the real problem.

Since its initial development and introduction by Texas Instruments, the 7400 series of ICs has become an industry standard—at least in terms of device functions and pin-outs. These chips are composed of a large variety of SSI-, MSI-, and LSI-logic building blocks, which designers put together to produce the desired functions.

The original 7400-series family consisted primarily of simple functions, like gates and flip-flops. These were adequate for many applications, but designers kept demanding devices with increasingly greater complexity and functionality.

IC technology did not stand still as designers needed more devices with higher speed and lower power. These requirements led to the introduction of the 74H00-series (high-speed) and 74L00-series (low-power) devices. For the most part, these new series maintained the device pin-outs established by the standard-TTL predecessors (the 7400 series). However, the 74H00-series devices consumed substantially more power than, and the 74L00-series devices were slower than, the standard 7400-series devices.

As the technology improved, even more families appeared. A faster family using Schottky technology was established, the 74S00 series, along with a popular low-power Schottky family, the 74LS00 series.

Eventually, the very-low-power CMOS devices that had been manufactured with 4000-series numbering shifted over to the more popular 74xx00-series pin-out and numbering scheme with the introduction of the 74C00-series family of devices. These devices were slow and had low-current-drive outputs, but

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they filled a niche in designs requiring extremely low power consumption.

Other families include 74ALS (advanced low-power Schottky), 74AS (advanced Schottky), 74HC (high-speed CMOS), 74HCT (high-speed CMOS, TTL-compatible), 74AC (advanced CMOS), 74ACT/74AHCT (advanced CMOS, TTL-compatible), and 74F (Fairchild advanced Schottky).

Simple Concept, Tough Trade-offs

Digitally speaking, the logical parameters of a 74xx00 are the same regardless of its family, and you could easily be misled into thinking that we are designing a digital tester. However, each of these families has analog characteristics that differ from the other families. The IC tester is actually more an exercise in analog design. Let me explain.

Typical differences between logic families are power consumption, speed, output current drive, input current loading, input transition thresholds, and output voltage swings. Comparisons of some of these parameters for a 74x00 quad NAND gate from several families are shown in table 1. (While the parameters specified in table 1 for the 74x00 devices do not apply to all devices within the respective families, they are representative of the majority of the devices).

In effect, table 1 shows the wide variations of input and output parameters that the ideal IC tester must support. Low-level input currents range from 1 microampere to 2 milliamperes (and much higher on some device inputs), and low-level output currents range from 360 μA to 20 mA.

The tester's ability to identify a device presents an important consideration. If the tester is designed for 74ALS or 7400 "straight" TTL, you might smoke a 74C chip if you inserted it into the tester operated at the current levels of those devices.

Any truly general purpose (read usable) tester must accommodate the wide ranging voltage and current parameters of all the families. Since the tester may not know at the outset what device is installed in the ZIF (zero insertion force) socket (remember, one of the modes is to identify unmarked chips), it cannot make any assumptions as to which pins are inputs and which are outputs.

The tester requires a certain amount of trial and error to identify an unknown device, and it must employ current-limiting resistors between the DUT (in the ZIF socket) and the IC tester's vector-generation circuitry (for when a DUT and tester output are connected together).

Also, while most devices have totem-pole outputs, some have tristate, open-collector, or open-drain outputs. The tester must be able to pull tristate outputs high and low when they are in the high-impedance state to verify the state, and it must also be able to pull open-collector and open-drain device outputs high and low to verify proper operation.

The catch-22 is to determine a resistor value that will support the input and output current specifications for all the device families to be tested, yet not overstress the DUT. If you go strictly by the book, no single current-limiting resistor value works for both inputs and outputs in all families.

The device specifications provided in table 1 are the manufacturer's recommended operating conditions (ROCs). Looking further into the data sheets, however, we find more information regarding what the chips can do if they have to, such as limited-duration short-circuit output current.

In effect, if we take advantage of our regulated testing environment, we can stretch the ROC a little to choose a resistor that presents the best compromise for handling all the logic families. Think of it as the electronic equivalent of poetic license.

All things considered, I found that the resistor value should be in the 390- to 421-ohm range. Since 390 ohms is the nearest

continued

standard resistor value (5 percent tolerance), I chose it for the tester. (After I built the tester, I substituted all standard resistor values between 300 and 430 ohms, inclusive, and verified that the 390-ohm choice provides the best overall performance.)

How It Works

After determining the above, I had one more hurdle. The tester needed to be able to apply virtually any number of test vectors to the DUT without losing the device's state from the previous vector--and without causing undo stress on the DUT (i.e., without keeping any of the DUT outputs in a high-current output mode for an extended period of time). I solved this with what I like to refer to as a combinatorial-latch circuit.

Each ZIF-socket pin typically has three circuit connections to the IC tester (see figure 1). One connection (connection A) is to

continued

Table 1: *Comparison of specifications for various 74xx00 devices. (Subscript identifiers are IL—input low, IH—input high, OL—output low, and OH—output high.)*

Device name	I_{IL} max	I_{IH} max (μA)	V_{IL} max (V)	V_{IH} min (V)	V_{OL} max (V)	V_{OH} min (V)	I_{OL} max (mA)	I_{OH} max (mA)
74LS00	−0.4 mA	20	0.8	2.0	0.5	2.7	8.0	−0.4
74H00	−2.0 mA	50	0.8	2.0	0.4	2.4	20	−0.5
74L00	−0.18 mA	10	0.7	2.0	0.4	2.4	3.6	−0.2
74S00	−2.0 mA	50	0.8	2.0	0.5	2.7	20	−1.0
74AS00	−0.5 mA	20	0.8	2.0	0.5	2.5	20	−2.0
74ALS00	−0.1 mA	20	0.8	2.0	0.5	2.5	8.0	−0.4
74HC00	−1.0 μA	1.0	1.2	3.15	0.33	3.84	4.0	−4.0
74HCT00	−1.0 μA	1.0	0.8	2.0	0.33	3.84	4.0	−4.0
74F00	−0.6 mA	20	0.8	2.0	0.5	2.7	20	−0.36
74C00	−1.0 μA	1.0	1.5	3.5	0.4	2.4	0.36	−0.36
7400	−1.6 mA	40	0.8	2.0	0.4	2.4	16	−0.4

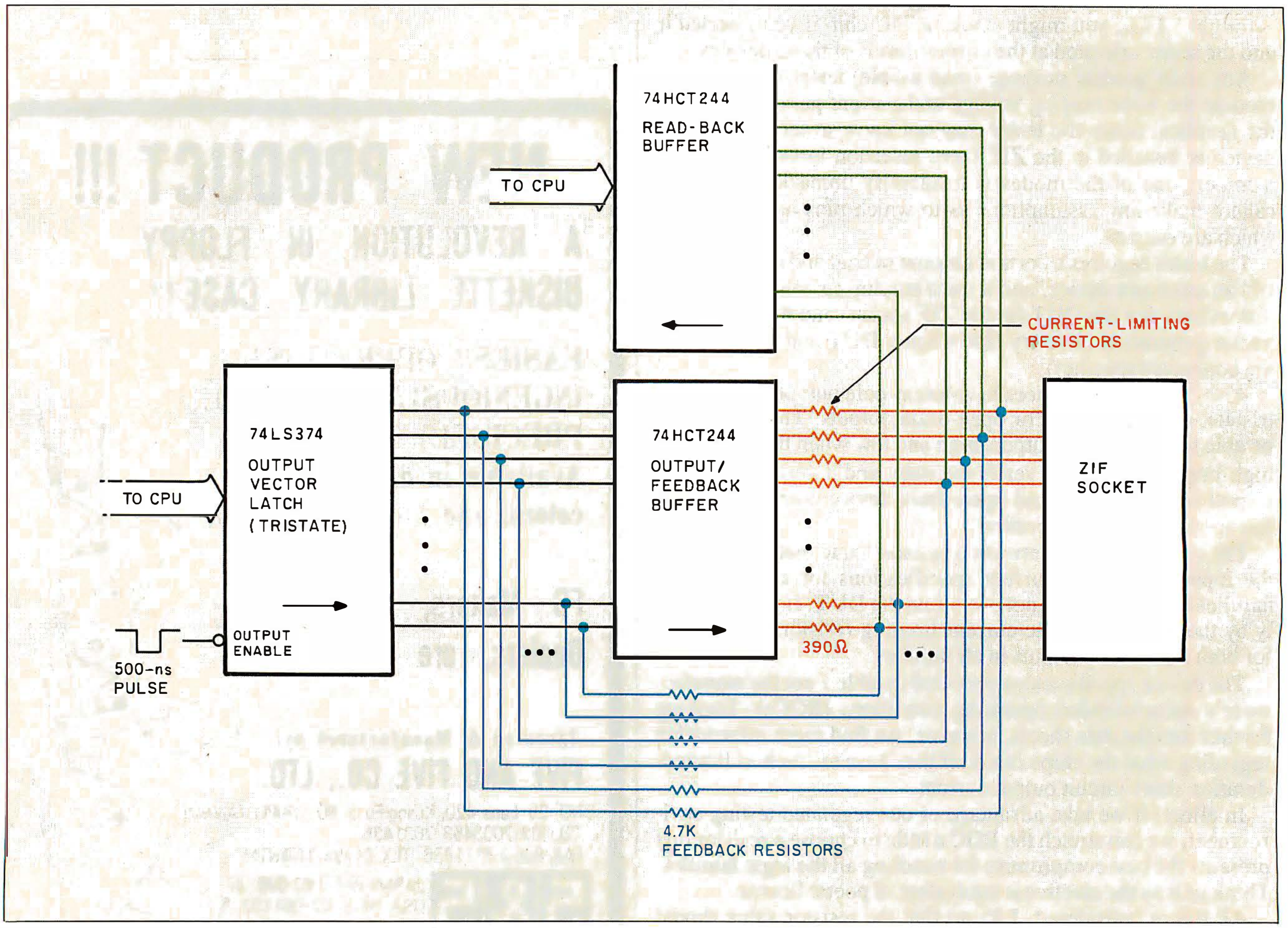


Figure 1: *Diagram of the IC tester's combinatorial-latch circuit. The zero-insertion-force socket holds the device under test.*



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The DB-25S connector provides the RS-232C interface connection to an IBM PC or any dumb terminal.

an output of a 74HCT244 buffer—the feedback buffer—through a series 390-ohm current-limiting/load resistor. Another connection (connection B) is to the corresponding input of the same 74HCT244, through a 4.7-kilohm series feedback resistor. The 74HCT244 input is also connected to an output of a 74LS374 tristate latch.

The final ZIF-socket-pin connection (connection C) is directly to an input of another 74HCT244 tristate buffer—the read-back buffer. By reading the 74HCT244 read-back buffer, the processor can determine the logic levels of the DUT pins (the ZIF-socket pins).

The IC tester sends a test vector to the DUT by writing the desired bit pattern into the 74LS374 latch, while the latch's outputs remain in the high-impedance state. The system then enables the outputs of the 74LS374 (i.e., they are allowed to go active) for a period of 500 nanoseconds, applying the test-vector bit pattern to the inputs of the feedback 74HCT244 buffer.

During the 500-ns 74LS374-enable period, the relatively high value of the feedback resistors (4.7 kilohms) ensure that the 74HCT244 inputs will see the test-vector logic levels from the 74LS374, regardless of the logic levels present at the DUT pins.

Within a few nanoseconds (i.e., propagation time) of the time the feedback 74HCT244 first sees the new logic levels from the 74LS374, the same logic levels will appear on the outputs of the 74HCT244; these logic levels will remain on the 74HCT244 outputs for the duration of the 500-ns pulse.

If a DUT output in the ZIF socket is in the opposite logic state as the corresponding 74HCT244 output, the resistor between the 74HCT244 output and the DUT pin will present a load to the DUT output, possibly causing it to go into its "overdrive" mode in an attempt to retain its desired output logic level. The overdrive operation will continue until the end of the 500-ns pulse, when the 74LS374 outputs are finally disabled, returning to their high-impedance state.

When the 74LS374 outputs are disabled, the only inputs to the feedback 74HCT244 will be from the DUT feedback resistors. Since the feedback buffer is a 74HCT-series device, it presents negligible input current loading (about 1 μA), so the voltage levels reaching the 74HCT244 inputs through the feedback resistors will be nearly the same as those at the corresponding DUT pins.

If the voltage coming through a feedback resistor to the 74HCT244 is the same logic level as that presented previously by the enabled 74LS374 output (the case when the DUT pin is an output of the same logic level or when the DUT pin is an input), the 74HCT244 output will remain unchanged. Thus, the logic level is combinatorially latched by the 74HCT244.

If the voltage appearing at the 74HCT244 input from the feedback resistor is the opposite logic level of that presented previously by the 74LS374 (which is the case when the DUT pin is an output of the opposite logic level), the 74HCT244 will see the new logic level at its input and change its output to match. When this occurs, the 74HCT244 output then matches the output of the DUT pin, eliminating the loading that was present. Again, the new logic value will be combinatorially latched by the 74HCT244 using the feedback loop.

You can see that the loading duration on a DUT output will essentially be the duration of the enable pulse—only 500 ns. This keeps potential chip stress to a minimum, while verifying the ability of device outputs to operate properly under load conditions.

The IC Tester Hardware

The schematic for the IC tester is shown in figure 2. The 8031 single-chip microcontroller (IC1) is the brains of the tester. The firmware to run the tester is provided in an EPROM at IC6. The current standard device library (version 1.0) is supplied on a 27256, but IC6 can accommodate several EPROM types, including 2764, 27128, and 27512 devices. The type you would use is determined by the JP1's jumper configuration.

The ZIF socket (IC17) is an Aries universal socket. This specific socket supports devices up to 24 pins, having either 0.3- or 0.6-inch DIP-package widths. When you insert devices into the ZIF socket, you bottom-justify them.

Unfortunately, one problem with using a single ZIF socket on a tester is configuring the power pins for the DUT. Most ICs conform to the standard diagonally opposite corner-pin power/ground configuration: pins 24/12, 16/8, and 14/7. However, a number of devices have oddball power and ground pin-outs. These include 14-pin ICs with ground on pin 11 and power on pin 4, 16-pin ICs with ground on pin 12 and power on pin 5, and 16-pin ICs with ground on pin 13 and power on pin 5, among others (there are also devices with two power pins to support voltage-level conversion).

After reviewing the devices in each oddball pin-out category, I chose to support the two categories with the most devices: 14-pin devices with ground on pin 11 and power on pin 4 and 16-pin chips with ground on pin 12 and power on pin 5. This is, of course, in addition to supporting devices having corner power and ground pins. (In the stand-alone identify-unmarked-chip operating mode, the tester will successfully identify only corner-pin-powered chips.)

The DB-25S connector provides the RS-232C interface connection to an IBM PC or any dumb terminal. The connector is configured as a DCE (data communication equipment) device, allowing you to use a straight-through cable. You need only three pins on the connector (pins 2, 3, and 7—receive, transmit, and signal ground, respectively), but I've hard-wired the DTR (pin 6) handshaking line to a logic high for terminals that need it.

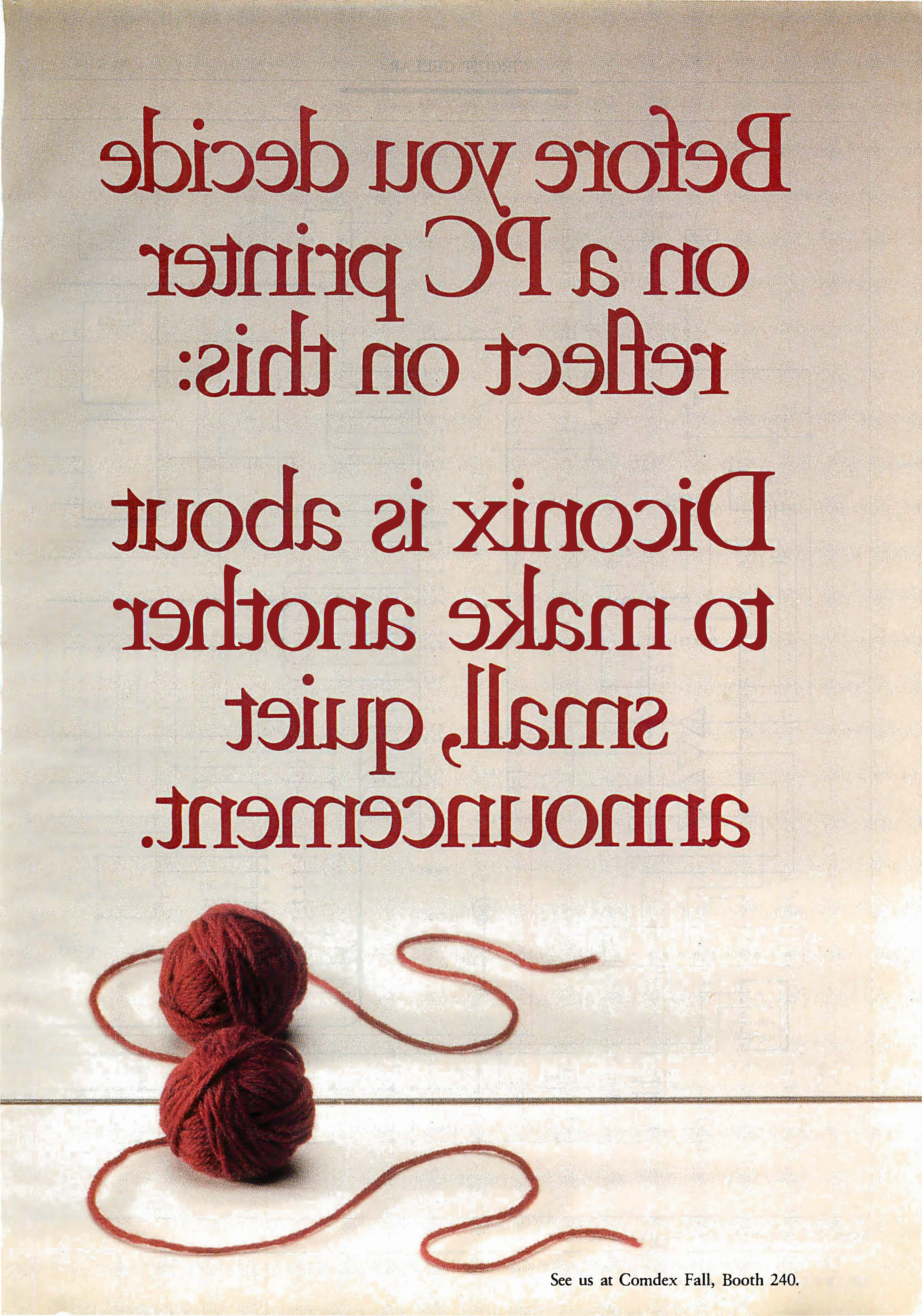
The IC tester has push buttons and some switch-selectable options. A four-position DIP switch (SW1) is used for several purposes, including data-transfer-rate selection, PC-host/terminal mode selection, and 74Cx mode selection (to be described next month). Push buttons PB1 and PB2 are for supporting stand-alone mode operation. PB1 is the identify button, and PB2 is the retest button.

J3 is the connector for the optional LCD, which uses the 8031's P1 connector as its data bus. I chose the P1 bus as the LCD's driver to meet the LCD's (relatively slow) timing requirements. The 74LS139 (IC7) is the address-decoding circuit for accessing several devices on the tester. It decodes the ZIF tristate latches (IC8 through IC10) and read-back buffers (IC14 through IC16), as well as the power/ground transistor latch (IC19).

The 74LS139 also provides a special signal that enables the outputs of the 74LS374 tristate latches for approximately 500 ns (the 8031 WR\ strobe duration), transferring the latched 74LS374 bits to the combinatorial latches formed by the 74HCT244s (IC11 through IC13) and their associated feedback resistors.

For the tester's buffers (IC11 through IC13), I chose 74HCT devices instead of 74LS (or other family) devices. Members of this family drive their outputs close to the power and ground rails, can source a lot of current, and provide negligible load on the resistor-feedback circuit. Similarly, the read-back buffers (IC14 through IC16) are 74HCT devices to keep loading to an

continued



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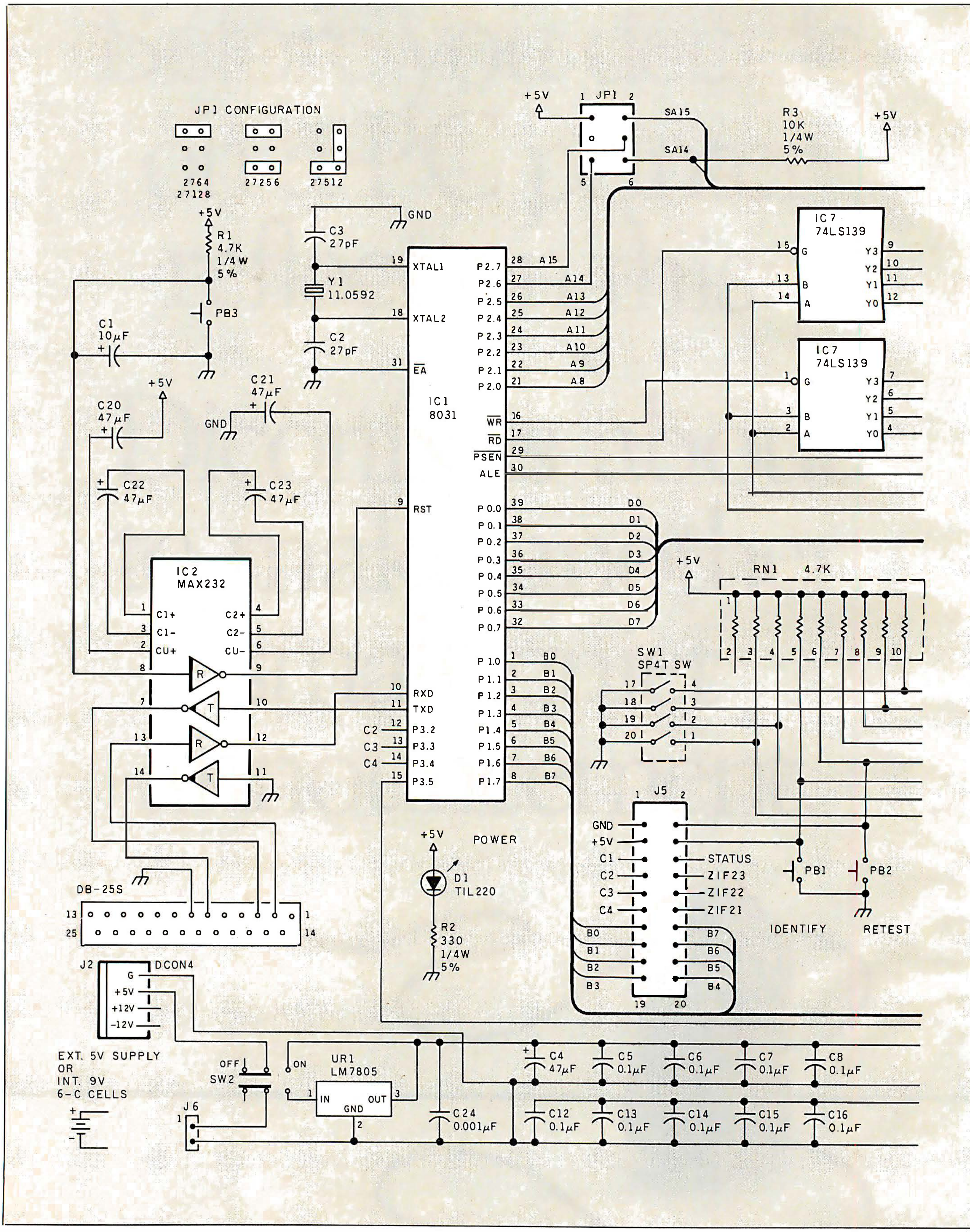
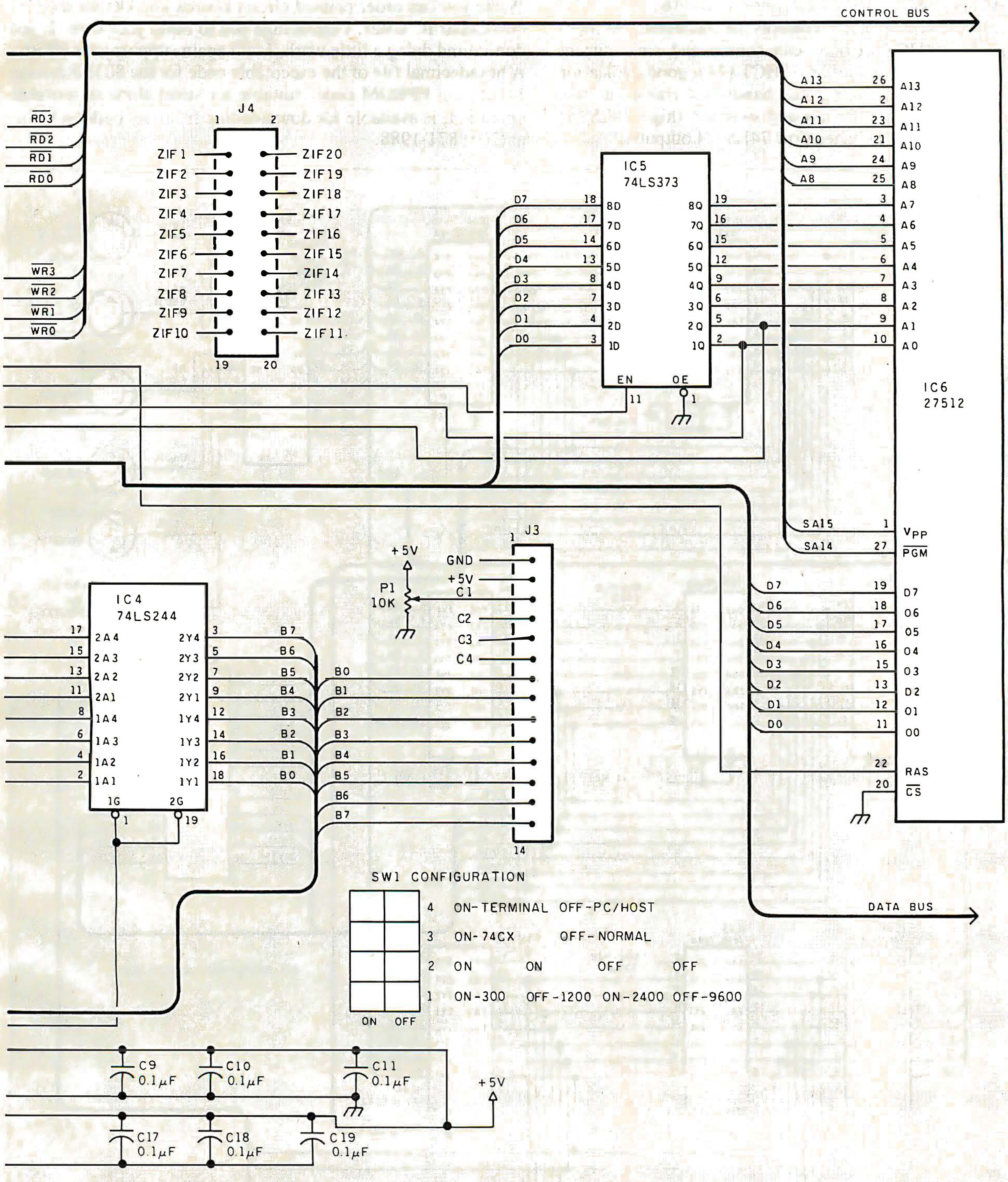


Figure 2: *Schematic for the Circuit Cellar IC tester.*


CONTROL BUS
RD3
RD2
RD1
RD0
WR3
WR2
WR1
WR0
J4
ZIF1 ZIF2 ZIF3 ZIF4 ZIF5 ZIF6 ZIF7 ZIF8 ZIF9 ZIF10
ZIF20 ZIF19 ZIF18 ZIF17 ZIF16 ZIF15 ZIF14 ZIF13 ZIF12 ZIF11
IC5
74LS373
EN
OE
IC6
27512
A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0
SA15
SA14
VPP
PGM
D7 D6 D5 D4 D3 D2 D1 D0
O7 O6 O5 O4 O3 O2 O1 O0
RAS
CS
J3
GND
+5V
C1
C2
C3
C4
P1
10K
IC4
74LS244
2A4 2A3 2A2 2A1 1A4 1A3 1A2 1A1
2Y4 2Y3 2Y2 2Y1 1Y4 1Y3 1Y2 1Y1
1G
2G
B7 B6 B5 B4 B3 B2 B1 B0
SW1 CONFIGURATION
4 ON-TERMINAL OFF-PC/HOST
3 ON-74CX OFF-NORMAL
2 ON ON OFF OFF
1 ON-300 OFF-1200 ON-2400 OFF-9600
ON OFF
DATA BUS
C9 0.1μF
C10 0.1μF
C11 0.1μF
C17 0.1μF
C18 0.1μF
C19 0.1μF

absolute minimum (do *not* substitute 74LS devices).

The discrete transistors (Q1 through Q6) provide the power and ground switching for the ZIF socket (IC17). Pin 24 of the ZIF socket is connected directly to +5 volts, eliminating the need for an additional transistor. The PN2907s (Q3 through Q6) are for turning on power (+5 V) to various ZIF-socket pins (9, 19, 20, and 22), while the PN2222s (Q1 and Q2) are for turning on ground to two of the ZIF-socket pins (12 and 16).

The 74HCT374 latch (IC19) controls the transistors. As mentioned earlier, 74HCT devices can source and sink current equally well. This fact made the 74HCT374 a good choice for driving the transistors, since it can handle the transistor base currents equally well for the ground switches (high 74LS374 outputs) and the +5-V switches (low 74LS374 outputs).

The tester has two LEDs. D1 is merely a power-on indicator that lights whenever power is applied. D2 is a software-controlled status LED used to indicate when the device is operating in an RS-232C mode (PC-host or terminal, LED on) or a stand-alone mode (LED off).

Experimenters

While you can order printed circuit boards and kits for the Circuit Cellar IC tester, I encourage you to build your own. If you don't mind doing a little work, I will again support your efforts. A hexadecimal file of the executable code for the 8031 Revision 1.0 system EPROM code, suitable for stand-alone or terminal operation, is available for downloading from my bulletin board at (203) 871-1988.

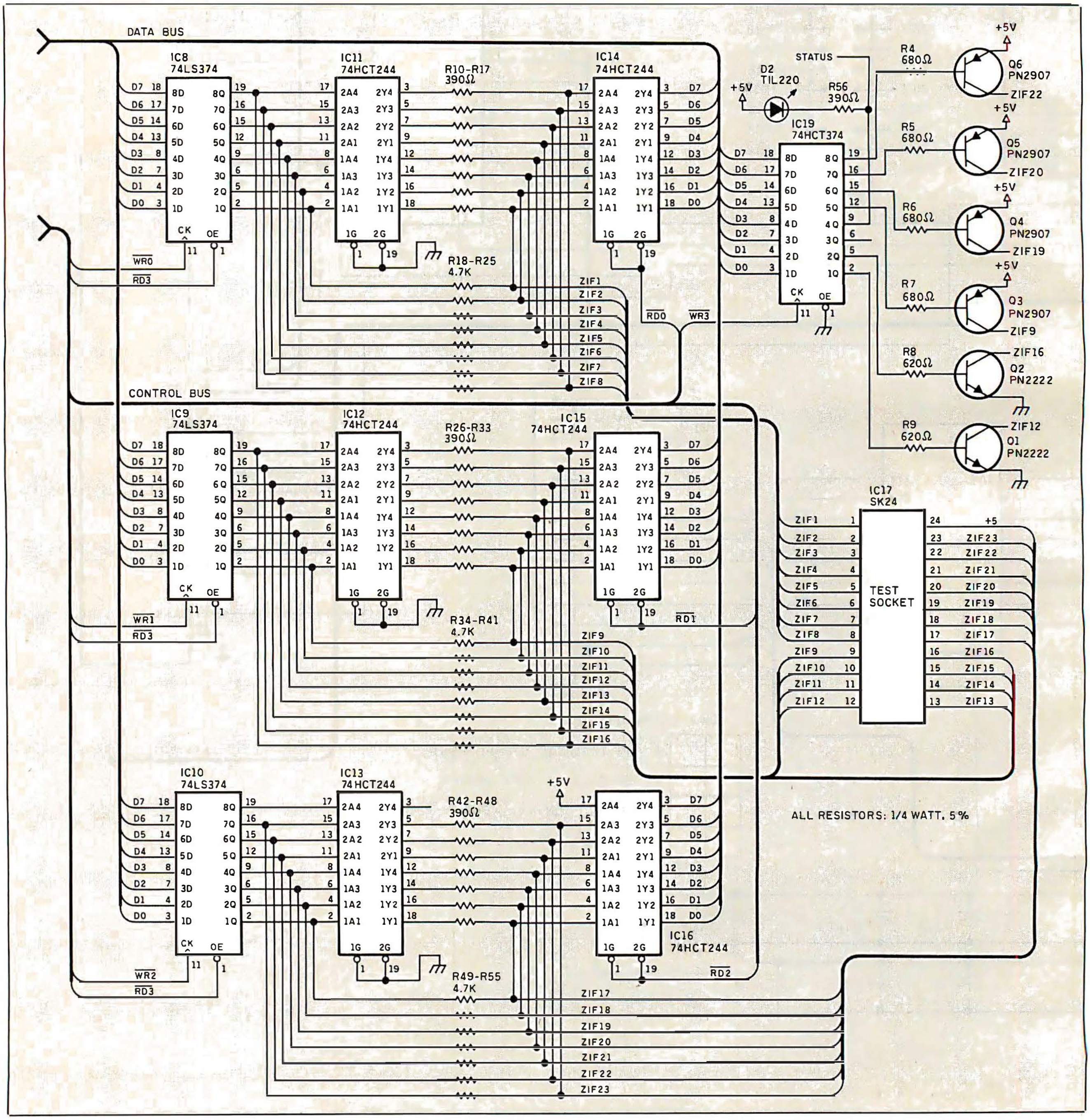


Figure 2: *Continued.*

Alternatively, you can send me a preformatted IBM PC 5¼-inch disk with return postage, and I'll put the file on it for you (the hexadecimal file could be used with my CCSEP serial EPROM programmer, for example). Of course, this free software is limited to noncommercial personal use.

Next Month

I will present the tester's software, which lets you develop and debug your own test vectors and device libraries. ■

Special thanks to Roger Alford, Jeff Bachiochi, and William Potter for their work on this project.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Company, P.O. Box 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers articles in BYTE from September 1977 through November 1978. *Volume II* covers December 1978 through June 1980. *Volume III* covers July 1980 through December 1981. *Volume IV* covers January 1982 through June 1983. *Volume V* covers July 1983 through December 1984.

The following items are available from

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1. Circuit Cellar IC tester experimenter's kit for stand-alone or terminal operation. Contains IC tester printed circuit board, 11.0592-megahertz crystal, programmed 27256 EPROM with Revision 1.0 device library, MAX232 level shifter, Aries 24-pin narrow-format ZIF socket, and manual with complete parts list.
ICT01-EXP $99
2. Circuit Cellar IC tester full printed circuit board kit for stand-alone, terminal, or PC-host operation. Contains IC tester printed circuit board, 8031 processor and crystal, programmed 27256 EPROM with Revision 1.0 device library, Aries 24-pin narrow-format ZIF socket, IC sockets, all board-mounted components and ICs, PC-host software on PC format disk, power supply, and manual.
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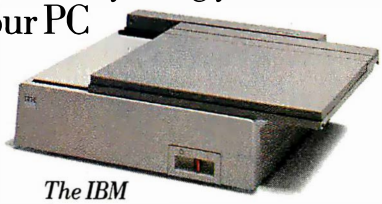


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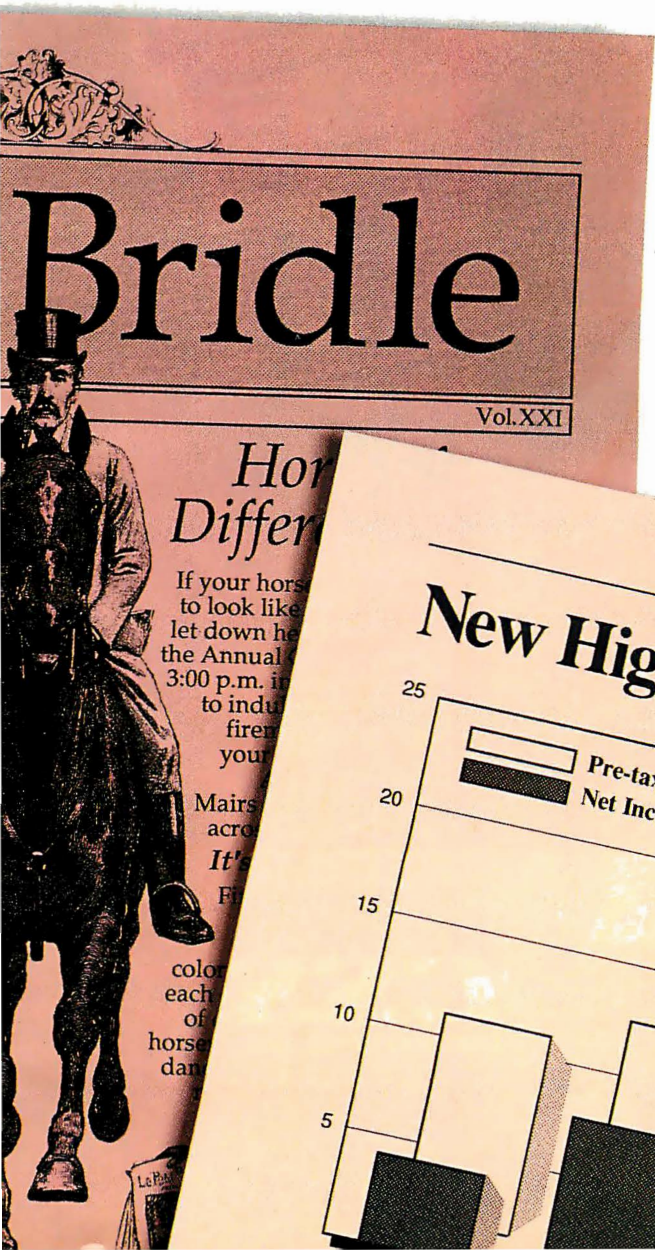
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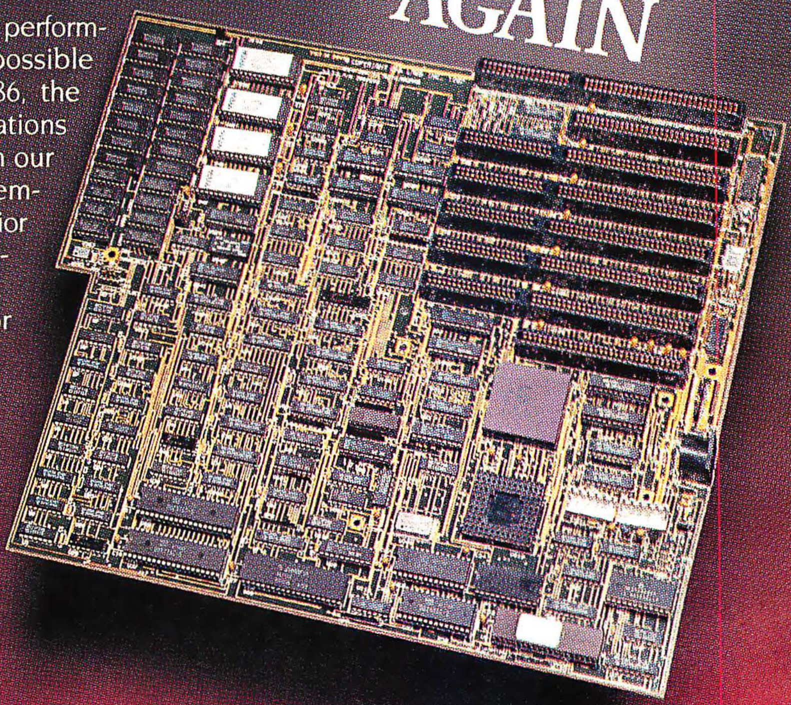


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Dick Pountain

Spraying and Smudging

Simulating the act of freehand painting involves some algorithms to "mix" colors as you would with a brush

I recently started writing a "freehand" painting program, and some interesting algorithms are cropping up during the endeavor. By "freehand," I mean a painting program that is intended to simulate the act of painting with a brush (or drawing with a crayon) as closely as possible, rather than being oriented toward producing straight lines, smooth curves, and boxes. The latter type of program I prefer to call a "drafting" program.

Drafting programs are designed to help people produce polished and professional artwork without requiring great drawing skill, and this is what has made Macintosh programs like MacPaint, FullPaint, and CricketDraw popular. A freehand drawing program, on the other hand, is more concerned with texture, stroke dynamics, and irregularity of all sorts; in short, in producing an uncomputerlike result.

A freehand program lets people who can already draw pursue this activity on a computer instead of by pen, brush, or crayon. Of course, the distinction is not nearly so rigid as this implies; MacPaint and similar programs have many freehand features (e.g., the spray can), while a freehand program needs to offer "computerish" features like editing and cut-and-paste composition if it is to have any advantage over a real brush. The difference is one of emphasis rather than of essence.

The features I require in a freehand drawing program include high resolution, a palette of at least 256 colors (preferably more), and lots of control over the drawing process. There must be sufficient processing power to let you make smooth sweeping strokes; an insufficiently quick response time causes bold strokes to break up into dots or become noticeably jerky and angular. You must be able to continuously vary the brush size on the fly to permit calligraphic effects; choosing from a limited range of discrete sizes on a menu is just not adequate.

As well as using solid colors, you should be able to lay varying tones in airbrush, or spray-can, style, and there has to be a positive and interactive way to blend, blur, smudge, stipple, scumble, mingle, and smooth colors once they're laid. This last process has provided some algorithmic interest.

Painting with Pixels

"Painting" on a VDU (video display unit) screen is, of course, physically quite different from painting on paper. For one thing, the colors are self-luminous rather than reflective. But more important, the colors are formed by a two-dimensional grid of uniform-size pixels with no depth, rather than by pigment particles suspended in a medium. Color effects are produced by a strict juxtaposition of pixels, with no overlapping.

"Mixing" colors on a VDU screen can be performed at two different levels. At a lower level, which gives a more visually uniform "mixture," you simply choose a new color from the palette midway between the colors you wish to mix (e.g., an orange lies between red and yellow). Here, "mixing" takes place at the level of the individual phosphor dots that make up the pixels.

On a system using analog video (like the Amiga or the Acorn Archimedes), you could automate the process, since the RGB content of each pixel's color is bit-mapped. Read the pixel colors on either side of a boundary; interpolate a color that has the averages of their red, green, and blue components; and then plot it. I don't find this useful; it's easier and much more flexible to choose a color manually and apply it with a "brush."

At a higher level—and more interesting for me—is the mixing of two colored areas by jumbling up the pixels at their boundary. This is an operation that can be performed after two adjacent areas have been painted with solid color, in order to soften or blur the boundary between them. In real painting, this sort of thing might be done with a dry brush, or with a finger in the case of pastels or pencils. It is important to simulate this effect convincingly if you are to go beyond "computerish" images composed only of flat colors with sharp boundaries.

Smudging can be simulated on a computer screen by the combined use of two basic tools. The first tool is simply an airbrush, or spray can, as popularized by MacPaint. This tool deposits pixels at random in a circular area around the cursor, at a rate fast enough to give the impression of a spray of drops but slow enough to allow density control; the longer you leave the airbrush on one spot, the darker the color becomes.

The airbrush is normally "filled with paint" of a single color; in other words, it changes pixels from their current color to the paint color. So, to smooth a boundary between red and yellow areas (see figure 1a), you could spray with either red or yellow. Figure 1b shows the boundary airbrushed with yellow paint.

The second tool I call a "smudger." Like the airbrush, it changes the color of random pixels in the area around the cursor. In this case, however, it does not add any new color at all. Instead, it takes the colored pixels that are already there and moves some of them across the boundary. In the above example, some of the yellow pixels are moved into the red area, and some of the red pixels are moved into the yellow area (see figure 1c).

The smudger, then, is just a pixel swapper. When used on an area of uniform color, it has no visible effect, though it is still

continued

Dick Pountain is a technical author and software consultant living in London, England. He can be contacted c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458, or on BIX as "dickp."

busily swapping pixels of the same color. In an interactive painting program, the smudger is used just as a brush is. Drawing it down a color boundary softens that boundary, and the effect can be controlled by varying the speed at which the smudger is moved; the longer it resides in one place, the more thoroughly it mixes the colors. Also, the smudger can be varied in size, just like other brushes.

Smudging Algorithms

The airbrush and the smudger have a similar-base algorithm, namely, one that selects random points within a circular area.

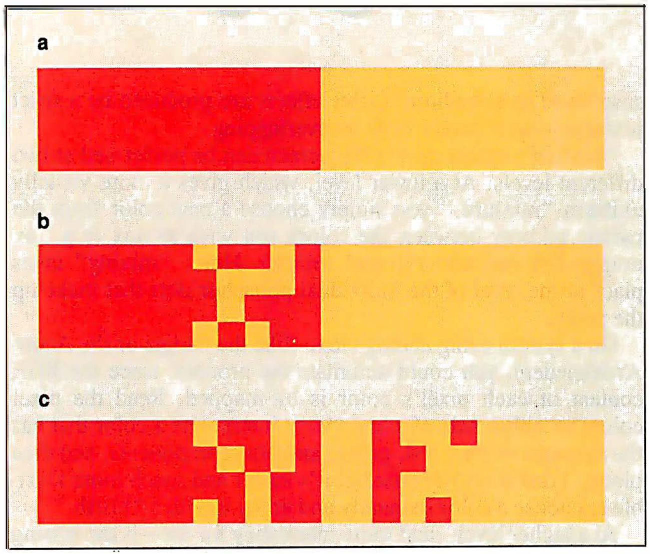


Figure 1: ***(a)*** *Two adjacent blocks of color sharing a hard boundary.* ***(b)*** *The boundary in (a) has been softened with a yellow-filled airbrush. (Each square equals one pixel.)* ***(c)*** *In this case, the hard boundary in (a) has been softened by smudging (i.e., by swapping pixels).*

Listing 1: *A pseudocode algorithm to determine random points within a circle.*

```
PROGRAM RandomCirclePoint
REPEAT
  X <- 2 * RANDOM(Radius) - Radius
  Y <- 2 * RANDOM(Radius) - Radius
UNTIL X² + Y² =< Radius²
```

Listing 2: *A pseudocode algorithm to swap pixels within a circle.*

```
PROGRAM Smudge
RandomCirclePoint
X1 <- CursorX + X
Y1 <- CursorY + Y
Color1 <- GETCOLOR(X,Y)
RandomCirclePoint
X2 <- CursorX + X
Y2 <- CursorY + Y
COLOR GETCOLOR(X2,Y2)
PLOT X1, Y1
COLOR Color1
PLOT X2,Y2
```

The difference between them is that the airbrush just plots such points in the paint color, while the smudger takes pairs of such points and swaps their colors.

Given the random-number generator found in most programming languages, it's not difficult to generate random points that lie inside a circle. The most obvious algorithm is one based on polar coordinates. Choose a random angle a between 0 and 360 degrees, choose a random radius r less than the radius of the desired circle, and the random point is $x = r \cos(a)$, $y = r \sin(a)$. However, this solution has the disadvantage of invoking not merely floating-point math but trigonometric functions, and these can be very slow in many microcomputer implementations. One way around this, if you have a lot of memory, is to precompute and scale the cosines and keep them as integers in a lookup table. The sines can be derived from the same table using the fact that $\sin(a) = \cos(90-a)$.

Alternatively, an equally good algorithm can be derived from the equation of a circle about the origin, $x^2 + y^2 = r^2$. Generate two random numbers x and y between $-r$ and r, the circle radius; compute $x^2 + y^2$, and if the result is greater than r^2, throw them away and choose two more; otherwise, x and y define your point. Listing 1 shows this algorithm in pseudocode, assuming that `RANDOM(n)` produces a random number between 0 and n; if your random-number generator is the sort that yields only numbers between 0 and 1, you'll need to multiply the result by n.

The airbrush tool is now trivial. It consists merely of generating a random circle point about the cursor position and then plotting it in the current paint color, to be repeated at a suitable rate that is determined by experiment.

A full drawing program will typically have a main loop that polls the buttons of a mouse or a graphics tablet, and here speed can be a problem; plotting just one point per main-loop iteration may not be fast enough to give the right interactive feel. The answer is to generate several points per main-loop iteration using in-line code and to derive more than one point from each random-number pair by exploiting symmetry.

The smudger is no more difficult than the airbrush. Just generate two random circle points and swap the colors of the pixels at those two points. If you're writing in assembly language, swapping colors may actually mean swapping the bytes at two screen-buffer addresses. In a high-level language, it means reading the colors of the pixels (with a special function called `GETCOLOR` or its equivalent) and replotting them (see listing 2). Given sufficient time, this will totally randomize the colors within the smudge circle. Again, achieving the speed needed to give the right feel in an interactive program can be a problem, and I needed to plot several points from each set of random numbers by exploiting symmetry.

Controlling the Spray

Both random-circle-point algorithms produce points that (subject to any whims of the random-number generator) are evenly distributed throughout the circular area. Every point in the circle may be selected with equal probability, and if you leave the airbrush pointed at the same spot, it will produce an evenly colored circle. If all you want is to be able to fill large areas with a uniform tint, such an airbrush would be ideal.

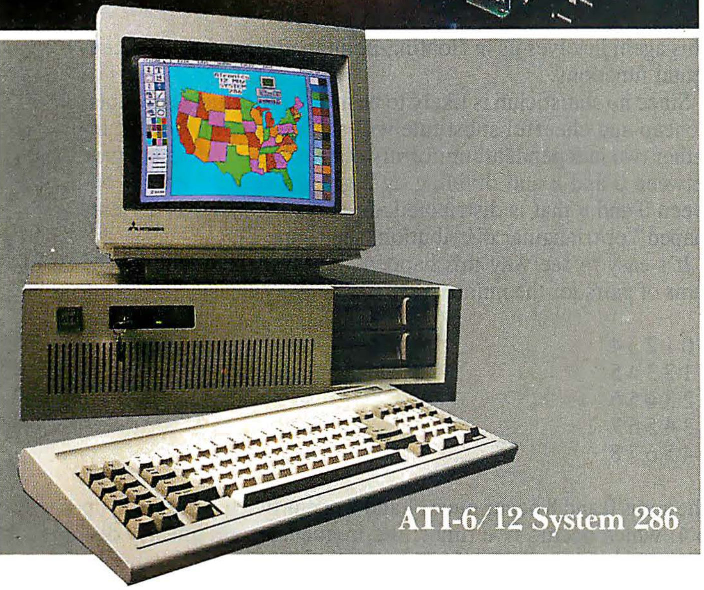
Real airbrushes, however, produce a nonuniform spray, in which the density of the droplets is greater at the center of the circle and falls off toward the edges. When using the airbrush to draw or shade complex shapes rather than to spray large areas, this behavior is much more suitable, as it is less likely to produce hard edges where the density changes too fast; it permits smoothly graded tones to be achieved. Moreover, on a real airbrush, you can vary the gradient of nonuniformity by altering both the distance of the nozzle from the surface of the work and

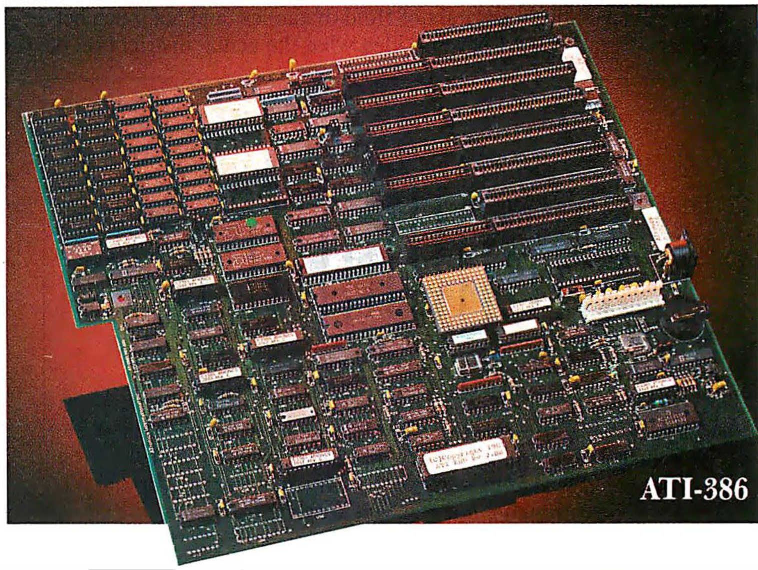
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the position of a needle valve on top of the airbrush.

How can we alter the frequency distribution of the random circle points to emulate this effect? The algorithm in listing 1 reduces this question to the more general one: How do you alter the frequency distribution of values from a random-number generator?

In researching the answer to this, I was surprised to learn that few algorithms actually generate nonuniformly distributed numbers. Instead, you have to use a uniform random-number generator and manipulate its outputs mathematically to produce the desired distribution. Donald Knuth includes a whole chapter on such techniques in volume 2 of his great opus, *Art of Computer Programming* (Addison-Wesley, 1981).

Being entirely ignorant of fluid dynamics (and not much better on statistics), I have no idea what the actual distribution of

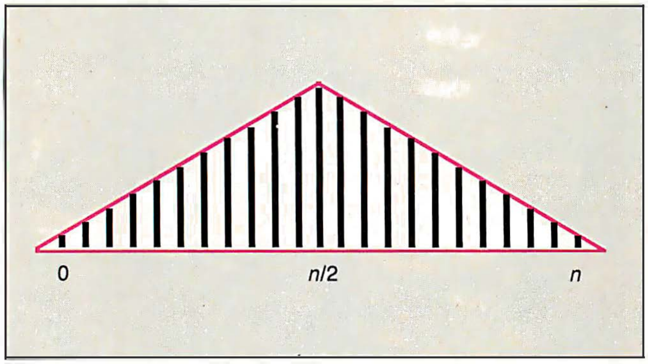


Figure 2: *The triangular distribution of random integers, calculated by adding series of two independent, uniformly distributed, random integers and dividing by 2.*

Listing 3: *An IBM BASICA program that displays the distribution of the sums of random numbers. Try substituting* RND *or* (RND+RND)/2, *etc., into line 150 to see the changes they cause in the curve.*

```
110 DIM A(20)               ' Array to hold frequency counts
120 RN=VAL(MID$(TIME$,4,2)+MID$(TIME$,7,2))
130 RANDOMIZE RN            ' Randomize the randomizer
140 FOR I = 1 TO 5000       ' This takes a while on a PC!
150   X = INT((RND+RND+RND)/3 * 20) ' RND between 0 and 20
160   A(X) = A(X)+1         ' Increment count for bucket X
170 NEXT I
180 CLS
190 FOR I = 1 TO 20         ' Print histogram of frequencies
200   PRINT STRING$(A(I)/10,219)
210 NEXT I
```

Listing 4: *A pseudocode algorithm that generates airbrush points, using the sum of four random numbers.*

```
PROGRAM NonUniformRandomCirclePoint
REPEAT
   X <- (RANDOM(Radius) + RANDOM(Radius)
    RANDOM(Radius) + RANDOM(Radius))/2 - Radius
   Y <- (RANDOM(Radius) + RANDOM(Radius)
    RANDOM(Radius) + RANDOM(Radius))/2 - Radius
UNTIL X^2 + Y^2 =< Radius^2
```

droplets from a airbrush nozzle is, but I'd bet that a normal distribution about the center would look alright.

Knuth has several algorithms for producing true normally distributed random numbers, but they represent overkill for my purpose here. For example, one of them involves choosing random x and y between 0 and 1 (i.e., within a unit circle) by the method used above, then the normally distributed numbers $x1$ and $y1$ are given by

$$s = x^2+y^2$$
$$x1 = x\sqrt{(-2 * \log_e(s)/s)}$$
$$y1 = y\sqrt{(-2 * \log_e(s)/s)}$$

This again involves us in floating-point math and slow transcendental functions.

Since no statistician is likely to be around to criticize my dots, a cheap and cheerful substitute will suffice. Merely adding together two independent, uniformly distributed, random integers between 0 and n and dividing by 2 gives a random integer between 0 and n that is distributed about the mean $n/2$ in a "tent-shaped" or triangular distribution (see figure 2).

It's easy to see why this happens if you make a table of the sums of pairs for the numbers 0 to 4:

0	1	2	3	4
1	2	3	4	5
2	3	4	5	6
3	4	5	6	7
4	5	6	7	8

The sums 0 and 8 occur once, 1 and 7 occur twice, and so on, up to 4, which occurs five times; the frequencies are linearly distributed about the mean 4. The "integer divide by 2" complicates matters because it rounds down, skewing the distribution so that 0 is three times as likely as 4; however, 2 (the mean divided by 2) is still the most likely value, with a $^9/_{16}$ probability:

0	0	1	1	2
0	1	1	2	2
1	1	2	2	3
1	2	2	3	3
2	2	3	3	4

By adding *three* random integers and dividing by *three*, a steeper distribution can be obtained. Following a similar argument, using tables, you can show that the frequencies in the distribution now approximately follow the sequence 1, 3, 6, 10, 15, . . . , which reminds me of the binomial coefficients derived by Pascal's triangle. The similarity brings up a very real question: Is this, therefore, a binomial distribution?

The frequency graph is now a rather blunt bell-shaped curve. Extending this principle by adding more random numbers together produces ever more "peaky" distributions. You can inspect these distributions for yourself in a graphical form by using the small program in listing 3, which is written in IBM BASICA and doesn't require a graphics adapter.

Other Options

Listing 4 shows a new algorithm employing the sum of four random numbers to generate airbrush points. I find it superfluous to make the gradient of the distribution itself a variable, as altering the diameter of the brush gives sufficient control.

There's lots of room to experiment with other weird distributions. Among the solid brushes, many different shapes apart from circular are useful; for example, oblique elliptical brushes can be used as pen nibs for calligraphy. Even some outrageously nonuniform airbrush distributions may have their uses. ■

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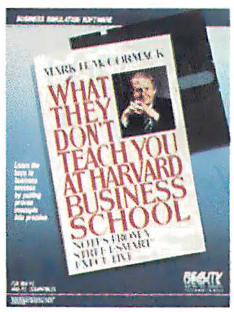
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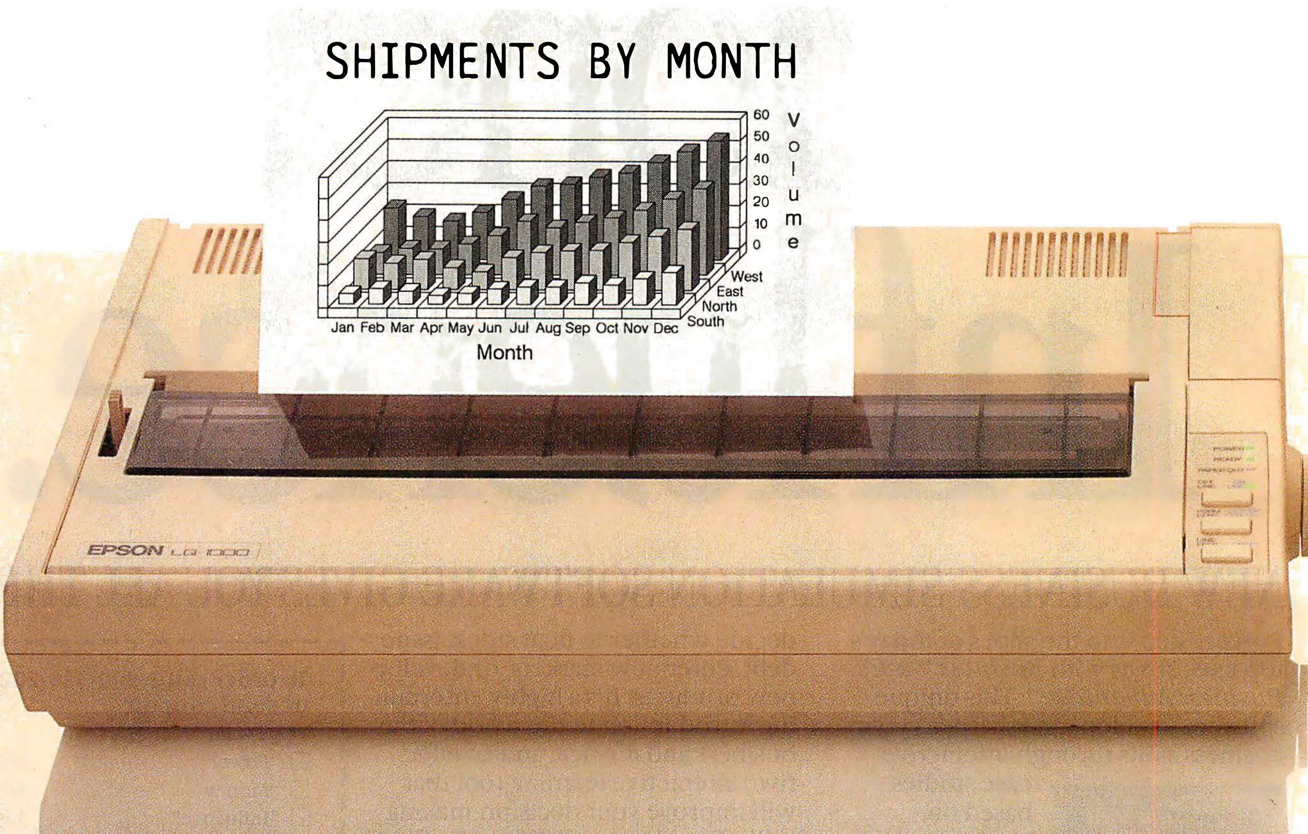
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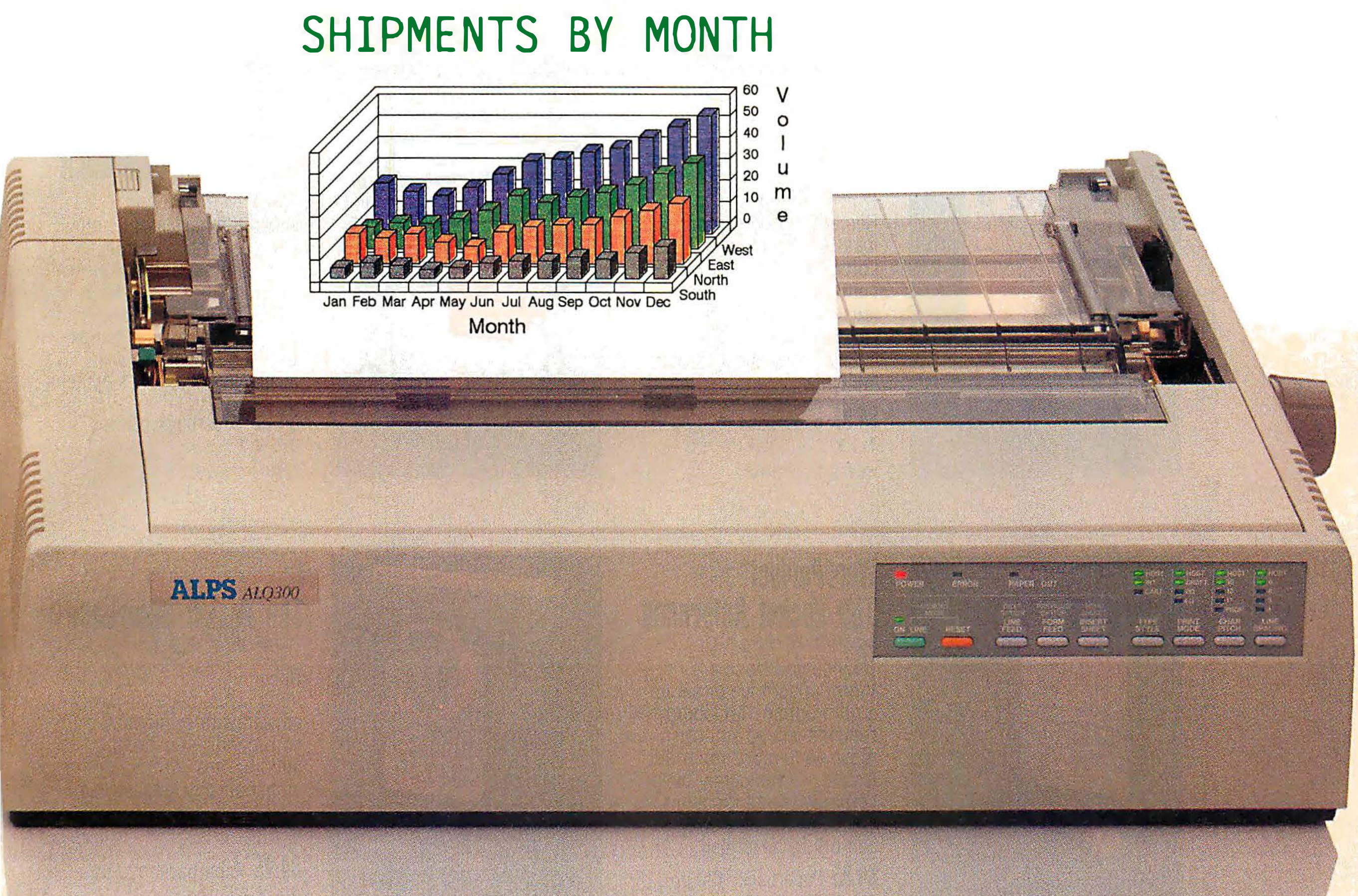
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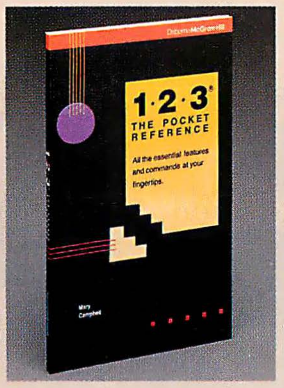
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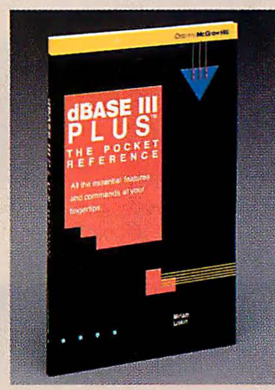
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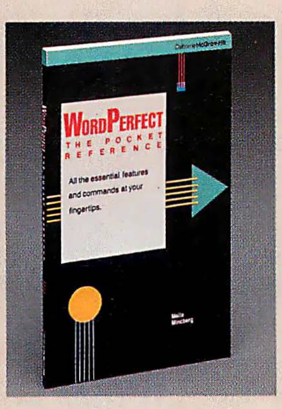
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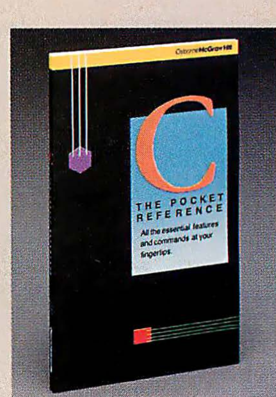
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Mike Morton

Recursion + Data Structures = Anagrams

Careful data structure design can lead to considerable improvements in your program's performance

Word-puzzlers through the ages have searched for anagrams with pencil and paper. They find it interesting to discover that the letters of the word *dormitory*, for instance, can be anagrammed to spell *dirty room*. This article explains the workings of a C program that can find all the possible anagrams for a phrase. It uses a recursive search, special data structures, and a text-file dictionary of words. The program is written in LightspeedC for the Macintosh but is generic and should run on other C compilers.

There are several approaches to using a computer to solve anagrams. In "Anagram Solving in Pascal" (July 1986 BYTE), Bob Keefer described a clever method that produces all permutations of the word's letters, then ranks each one using trigram probabilities to indicate likely candidates for real words.

Another approach is to use a good-size dictionary, stored in memory, as a source of letter groups to be "subtracted" from the letters of the original word or phrase until no letters are left. A simple implementation of this strategy would work but would be very slow and would take up enormous amounts of memory and disk space. By optimizing the way letter groups are stored and manipulated, however, I have created a program that is acceptably fast and efficient. On a Macintosh, the program reads a compressed word file of 142K bytes in about a minute and immediately starts producing anagrams at the rate of 4 per second.

A Dictionary-Driven Approach

The first step in creating an anagram program that is reasonably small and reasonably fast is to manipulate the dictionary intelligently. When the program examines your phrase, it can immediately reject many of the words in the dictionary. For instance, in searching for anagrams for the phrase *BYTE magazine*, the word *lazy* is ignored because the original phrase lacks the letter *l*. This preprocessing leaves a core of usable words, typically numbering a few hundred to a few thousand. But how can it find the combinations of these words that are anagrams?

The combinations are found with a tree search in which candidate words are repeatedly subtracted from an alphabetized set of the letters in the original phrase. For example, *BYTE magazine* begins as the list *aabeegimntyz*. Each branch down from a node corresponds to a word that can be made from letters in the node. The node that a branch leads to is the letters left when the branch's word is subtracted from the node's letters. For example, starting from the original node and taking the branch for the word *amazing* leaves the letters *beety* in a subnode. When a path leads to an empty node, the sequence of words along that path is an anagram.

Not all paths lead to an anagram. When *bye* is taken away from *beety*, only the letters *et* remain. Unless your dictionary has Latin conjunctions or names of aliens, this is a dead end in the search.

Listing 1 shows the pseudocode for a search procedure; ignore the `Push` and `Pop` statements commented out (I'll explain later). It uses an unspecified data type called `string` to hold words and sets of letters. We'll use two subroutines: `Subtract`, which removes all the letters of a word from a set of characters, and a Boolean-valued function `Fits`, which tells you if you can subtract a word from a set.

The procedure assumes that all usable words are stored in the array `words[1..numwords]`. For the letters passed to it in the variable `node`, the procedure considers all words to see if they can be subtracted from `node`. For instance, if the remaining letters are *beety*, some of the words that would fit are *yet*, *bye*, and *tee*. When a word fits, the program subtracts it from the node's letters. If letters remain, the search procedure has not found an anagram and recursively calls itself. If no letters remain, the program has found an anagram: the sequence of words that were subtracted.

The trouble is that nothing is remembering which words got subtracted. Each level of the recursion stores one factored-out word in the local variable `word`, but no part of the program has access to all its values.

The best way to keep track of the words used is to use a stack (take out the comment characters around the `Push` and `Pop` statements to allow the use of the stack). Whenever a possible word is found, it's pushed on the stack before the recursive call. When no letters remain, the words that produced it are on the stack and can be used to produce the anagram.

Choosing Appropriate Data Structures

This basic approach works, but it's a slow algorithm. One way to cope with that is by customizing the data structures used. Here are some of the choices:

- *Character strings or arrays:* These are simple to implement, since most languages support them and they represent words or sets of letters exactly and intuitively. Writing the `Subtract` and `Fits` procedures isn't hard, but they're extremely slow.
- *Frequency tables:* If you use an array of 26 integers to represent a word, with each one holding the count for one letter of the alphabet, things get a bit faster. The `Fits` procedure compares

continued

Mike Morton has a B.A. in mathematics from Dartmouth College. He is currently enrolled in the masters program in information and computer sciences at the University of Hawaii. You can reach him at P.O. Box 11378, Honolulu, HI 96828.

Listing 1: *Pseudocode for a recursive-search anagram program. Delete the comment symbols around the lines containing* Pop *and* Push *to create a stack of words containing the partial anagram (see text for details).*

```
procedure TreeSearch (node: string)
  var
      wn: integer              (* index of word to try to
                                  remove *)
      word: string             (* the word itself *)
      newset: string           (* result of "node" minus
                                  "word" *)

  for wn := 1 to numwords      (* loop through all
                                  possible words *)
      word := words [wn]       (* get the n'th word from
                                  the list *)
      if (Fits (node, word))   (* can word be made from
                                  node? *)
      then begin
        newset := Subtract(node, word)
                               (* find remaining letters *)
          (* Push(word)   *)

        if (newset = "")       (* nothing left? *)
        then PrintAnagram      (* empty node! a
                                  complete anagram! *)
        else TreeSearch(newset)
                               (* not empty; keep searching *)
          (* Pop   *)
      end                      (* end of handling word
                                  which Fits *)

end TreeSearch                 (* simple, eh? *)
```

two arrays, element by element, making sure each count is high enough to allow the subtraction of the second from the first. To remove the elements of one array from another, just subtract their corresponding integers. You could even combine the operations, subtracting each pair and checking to see if any of the results are negative.

This is faster, but it takes up lots of space. If you use byte-size integers, storing 5000 eligible words requires about 130,000 bytes of memory. As you'll see, things can be packed much tighter and still be faster.

• *Bit maps:* Suppose you're willing to limit yourself to phrases without repeated letters. You can encode a word in 26 bits, stored in a 32-bit long integer. Then this C macro can perform the Fits calculation:

```
#define Fits(node,word) ((node & word) == word)
```

In other words, are all the 1-bits in word also 1-bits in node? Subtraction is even easier—you just arithmetically subtract the word from the node to find the remaining letters.

This method is very fast, but it is crippled by the limitation of no repeated letters. (If you want to compute pangrams (anagrams for the alphabet), this data structure is ideal.) Still, the idea has merit and you can modify it to work without any limitations.

• *Variable-length, packed fields:* This combines the best features of the frequency and bit map methods. We'll use a count field for each letter in the original phrase, making each field the minimum possible number of bits. If you pack the fields into one or more long integers, you can rapidly manipulate them together. The placement of fields in the data structure depends on the phrase being anagrammed.

Imagine the phrase *BYTE magazine* stored in 26 integers, as

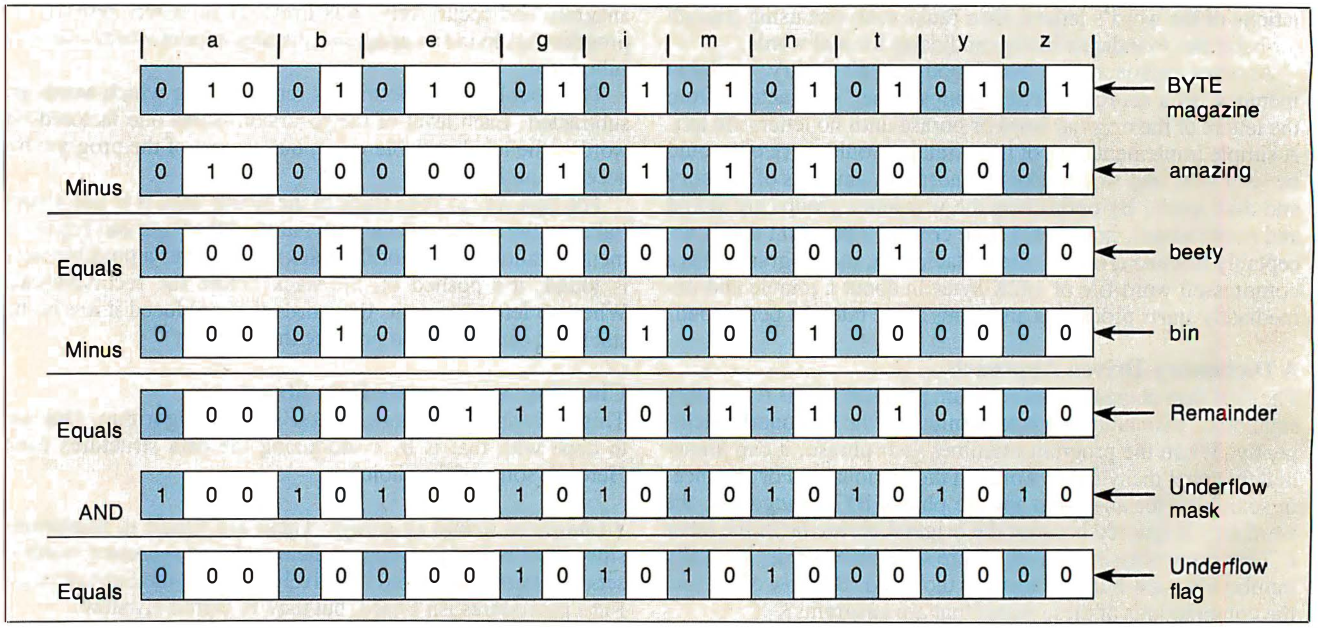


Figure 1: *Subtracting signature bytes to determine if a given word is contained in a given letter set. Rows 1 through 3 show how the word* amazing *can be subtracted from the letters in the phrase* BYTE magazine *to give* beety. *Variable-length fields with an underflow bit at the left end of each one represent the letters in the phrase. We know the subtraction is valid because all the underflow bits (shaded) in the result are zero. Rows 3 through 7 show what happens when you try to subtract out a word not contained in the letter set. By using the underflow mask to extract only the underflow bit from each character frequency field, the nonzero amount in the last line shows that the letter set* beety *(line 3) does not contain the letters in* bin *(line 4). For brevity, we omitted the ANDing with the underflow mask in the first subtraction; it would have returned a zero result, indicating a successful subtraction.*

described before. The letters *aabeegimntyz* are tallied up and the table reads 2, 1, 0, 0, 2, 0, 1, and so on. These are the maximum values that each field can have during the search, so you can choose field sizes appropriately. A count of 0 means that the letter doesn't occur and doesn't need a field. A count of 1 needs a single-bit field. A count of 2 (10_2) or 3 (11_2) will need two bits. In general, a frequency count F needs (int($\log_2$(F)) + 1) bits allocated for it. (If you don't have a $\log_2$ function, you can compute it easily by repeatedly shifting F one bit to the right and counting how many shifts are needed before the result is zero.)

Suppose you compute the field widths for all the letters occurring in a phrase, then pack them together in a single integer. (It may take more than a single integer, but we'll keep things simple for now.) You can encode every word by shifting each letter's frequency to the appropriate position.

(Note that words that have more of any letter than the original phrase can't be encoded because the fields may overflow; this is why it's important to select usable words first. Note also that the frequency numbers apply to the set of letters in the unrepeated, alphabetized letter set made from the original phrase. Thus, the frequency numbers for *BYTE magazine*, 2, 1, 2, 1, 1 . . . , refer to the letters, *abegi* . . . of the alphabetized phrase, not the *abcde* . . . of the alphabet. See the first row of figure 1.)

The first three rows of figure 1 show how a straight arithmetic subtraction subtracts the word *amazing* from *BYTE magazine* to leave the letters *beety*. In many cases, this is as fast as the method that used single bits. Only when there are enough letters with high enough frequencies will the collected fields need a second integer to store them all.

Detecting Underflow

The above example demonstrates that you can use arithmetic subtraction to remove the letters of a given word from a given letter set (this is the `Subtract` procedure in listing 1). But how do you determine whether the target word can be subtracted from the letter set (the `Fits` procedure)?

The solution is the frequency table approach: subtract, then see if underflow has occurred. To do this, you need to enlarge each field by one bit at the left end (which has already been done in figure 1). This new bit, one for the frequency group of each letter, is a 0 for the starting letter set and for each candidate word for subtraction. If a subtraction removed more letters than were available, a borrow from a higher bit will make the flag bit a 1. If the subtraction leaves any of these telltale bits on, that's the equivalent of finding (belatedly) that the `fits` function would have returned a value of *false*.

Knowing the arrangement of the fields, you can build a mask that contains all the underflow bits. Logically ANDing this mask with the result of a subtraction reveals whether any of these bits were tripped by subtracting. Figure 1 shows two subtractions, one successful and one not (for reasons of space, we did not check the underflow bits—which would have been 0—for the subtraction of *amazing* from *BYTE magazine*). The second one, the subtraction of *bin* from *beety*, is ANDed with the underflow mask in the diagram. The nonzero result indicates that we cannot extract *bin* from *beety*. Notice that the borrow in the *n* column invalidates all the character counts to the left of this, but this doesn't matter. Once you discover that *one* letter is missing, you do not need to know how many others, if any, are also missing.

Data Structures

Listing 2 shows the C implementation of some of the important data structures. [Editor's note: *For those who don't use C every day, keep in mind that the first element in an array is array[0].*] The fields for a long phrase may not fit into one bitmask, so bitmasks are grouped in arrays of up to `MAXMASKS` elements. I used the new type name `bitmask` to ensure program portability. This array forms the fundamental data structure for the program: the bit signature type `bitsig`. The program uses signatures to store phrases, words, collections of letters, and the underflow mask. Figure 2 shows a bit signature's structure.

Listing 2: *C data structures used in the program. This listing and listings 3 through 6 are code fragments from a working anagram program, ARS.C.*

```
/**** The anagram-equivalent of a word is stored in a "bit
      signature." ****/
#define bitmask         long        /* a "bitsig" is made of
                                       "bitmasks"*/
#define MAXMASKS        3           /* at most this many masks
                                       per signature */
typedef bitmask bitsig[MAXMASKS]; /* so, a bit signature
                                       looks like this */
#define maskwidth (8*sizeof(bitmask)) /* number of bits
                                           per bitmask */

/**** Global information about the phrase being
      anagrammed: ****/
int freqs [26];                     /* frequency distribution
                                       of phrase */
bitsig uflosig;                     /* bit signature to detect
                                       underflow */

/**** Each letter in the phrase has a field in the bit
      signature: ****/
int letmask [26];                   /* which mask is each
                                       letter's field in? */
int letbit [26];                    /* what bit # does each
                                       field start at? */
int letwidth[26];                   /* how wide is field for
                                       each letter? */
int lastmask;                       /* highest mask # used
                                       (0..MAXMASKS-1) */

/**** Dictionary information: ****/
char **wordlist = NULL;             /* dynamic array of
                                       pointers to words */
int maxwords = 0;                   /* wordlist has bounds
                                       [0..maxwords-1] */
int numwords;                       /* usable words are in
                                       [0..numwords-1] */
char *textnext = NULL;              /* next character to store
                                       a word at */
int textleft = 0;                   /* characters left in
                                       current text chunk */
bitmask *wordsigs;                  /* bitsigs for usables;
                                       [0..numwords-1] */

/**** For printing anagrams: ****/
char *anawords [STACKMAX];          /* recursion stack to
                                       remember words */
char **anaptr;                      /* stack ptr (points to
                                       1st unused slot) */
long anacount = 0;                  /* total number of
                                       anagrams found */
```

Because the field widths in a bit signature are different for every phrase to be anagrammed, the program must keep track of where each letter field begins and how long it is. The arrays `letmask`, `letbit`, and `letwidth` do this. To find where the field for the letter *z* is, `letmask[25]` tells which bitmask in the signature holds it, `letbit[25]` specifies the rightmost bit of the field, and `letwidth[25]` tells the field's bit width. This is only to generate bit signatures during startup, not during the search.

Storing the words is an exercise in data structures, too. If you

continued

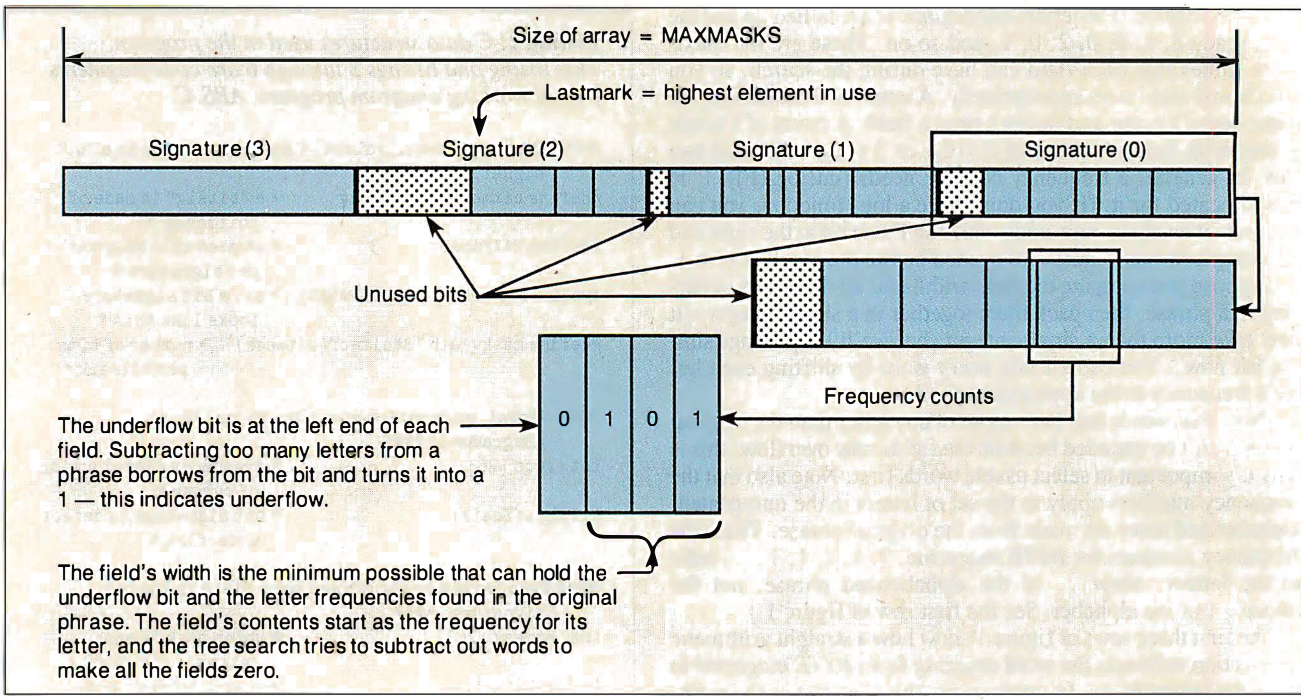


Figure 2: *The "bit signature" data structure. This is a collection of fields, each holding the frequency of a given letter and an underflow bit. To simplify the algorithm (and to allow the use of arithmetic subtraction to do the subtraction of signatures), the author designed the structure so that frequency-count fields do not cross physical boundaries—longwords, in this case.*

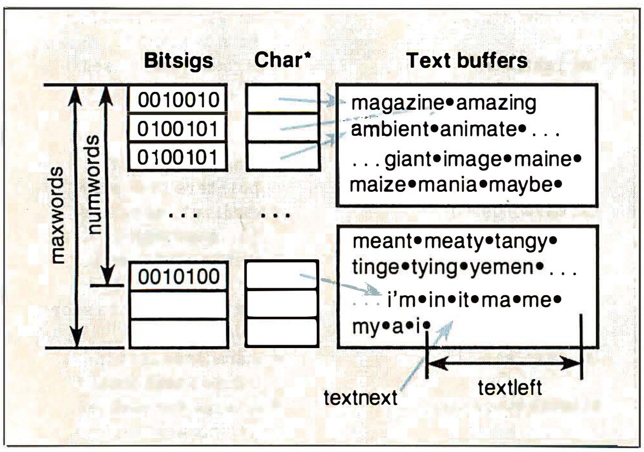


Figure 3: *Storing candidate words for easy use during the anagram search. The search needs both the bit signature and text for each word. These are kept in parallel arrays; both the maximum length and used length of the arrays are remembered. The variables* `numwords` *and* `maxwords` *keep track of the number of entries left in the two arrays, while* `textnext` *and* `textleft` *do the same for the text buffer area.*

call a typical memory allocator a few thousand times to store the words, it might take too much space or time. I chose to allocate large buffers and carve them up to store the words. In figure 3, each candidate word is stored in two arrays and a text buffer: Its signature is stored in an array of `bitsigs`; the word itself is stored at the tail end of a text buffer and is pointed to by the corresponding entry from an array of character pointers. The variable `numwords` points to the next available entry in the `bitsig` array, and `maxwords` contains the maximum number of candidate words the program can handle. The variable `textnext` points to the next free character in the current buffer, while `textleft` keeps track of the number of bytes left in the buffer. When `textleft` is too small to fit another word, the program allocates another buffer.

The stack is just an array of pointers to characters and the stack pointer is a pointer into the array. The program initializes the stack pointer (`anaptr`) to `anawords[0]` before the search begins.

Important Subroutines

You can write most of the program from the description above. [Editor's note: *ARS.C, a machine-independent C program written in LightspeedC, is available on disk, in print, and on BIX; see the insert card following page 384 for details. It is also available on BYTEnet; see page 4. The Boston Computer Society's Mac subgroup sells a disk containing an enhanced shareware program, Ars Magna (no source code), and associated dictionary files. You can order Ars Magna for $10 ($5 for BCS members) plus $2 for shipping from: BCS•Mac, One Center Plaza, Boston, MA 02108.*] Listings 2 through 6 (all excerpted from `ARS.C`) show the key C functions of the program and are described below.

• `choosefields`: This routine (see listing 3) decides where in the bit signature each letter's field will go. It uses the frequency distribution numbers (filled in earlier) and produces the `letmask`, `letbit`, and `letwidth` arrays. It also sets `lastmask`, the highest-numbered mask used in a bit signature, which is always in the range `0..MAXMASKS-1`.

The function starts by setting `curmask` and `curbit` to 0. It examines each letter and processes only the ones that occur in the original phrase. For letters that do occur, it calculates the width (in bits) of a field for that frequency. If there's not enough room in the mask being used, it skips to the next mask in the signature and starts at bit 0 of that mask. The choosing of fields,

continued

as done in this routine, must occur before the program can create the underflow mask and encode candidate words into their signatures.

• makeonesig: Encoding a word is simple once you know where the fields go. The makeonesig function (see listing 4) takes a character string and creates its signature. It first makes a frequency table for the string. Then, for every letter l, it finds which mask in the signature that letter's field lives in from letmask[l]. [Editor's note: *The references in this and the next paragraph to* l *are to a C program variable named* l*, not to the numeral "1."*] Then it shifts over the frequency by letbit[l] to place it in the correct field, and adds that into sig[letmask[l]].

• makeuf: Building the underflow mask is straightforward, too. The makeuf function (see listing 5) just loops through the letters, much like makeonesig, and stores a count in each field. The difference is that for letter number l, the count stored is the highest bit in that field. This is found by shifting a 1 bit left by letbit[l] to position it in the field and then further by (letwidth[l] − 1) to move it to the top bit in the field.

* findanagrams: This recursive search function does the main work of the program (see listing 6). It receives a node, which may be the complete phrase or the phrase with some letters already removed. It also gets the array index of the last word that was stacked; this allows it to avoid permutations of the same anagram. For instance, it will print *amazing yet be* but not *yet be amazing* or any of the other possible word permutations (there are 6 in all). This is a standard technique used to avoid permutations in any recursive search.

The function works much like the pseudocode in listing 1. The main differences are that the word index is passed during recursion to avoid permutations, and there is no explicit test like the fits function; instead, it tests the result of the subtraction for underflow.

The heart of the search routine is a loop through the eligible words, with a parallel loop variable, cursig, going through their signatures. It starts at curword, not 1. For each word, it subtracts that word's signature from the current node's signature to generate the new node's signature. If this result has any underflow bits set, the word can't be spelled with the letters in that node.

continued

Listing 3: The choosefields *function. This routine assigns count fields based on the frequency of letters in the phrase to be anagrammed.*

```
choosefields (freqs)
  int freqs [];                   /* INPUT: phrase's
                                     frequency table */
  /* GLOBAL OUTPUT: letmask[], letbit[], letwidth[],
     lastmask */
{
  int letter;                     /* letter value (0..25) */
  int curmask = 0, curbit = 0;    /* initial mask and bit
                                     numbers */
  int width;                      /* fieldwidth of letter's
                                     field */

  for (letter = 0; letter < 26; letter++) /* loop through
                                             all letters */
  if (freqs[letter] != 0)         /* any occurrences of this
                                     letter? */
  {                               /* yes: find where it'll
                                     go */
    width = fieldwidth (freqs [letter]); /* how much room
                                            does it need?*/
    if (curbit+width > maskwidth)
                                  /* too wide to fit
                                     in rest of this mask? */
    {                             /* yes: have to kick into
                                     next mask */
      if (++curmask >= MAXMASKS)
                                  /* next mask number;
                                     is there room? */
        die ("Sorry: phrase too long to handle.\n");
                                  /* nope */
      curbit = 0;                 /* start at 1st bit of next
                                     mask */
      }                           /* end of kicking into
                                     next mask */

      letmask [letter] = curmask;
                                  /* note which mask this
                                     letter goes in */
      letbit [letter] = curbit;   /* ...and bit position in
                                     the mask */
      letwidth [letter] = width;
                                  /* ...and the width */
      curbit += width;            /* advance past this bit
                                     field */

    }                             /* end of handling char
                                     found in phrase */

  lastmask = curmask;             /* remember highest used
                                     mask number */
}                                 /* end of choosefields() */
```

Listing 4: *The* makeonesig *function, which encodes a string, storing frequency counts in the fields allocated by the* choosefields *function.*

```
makeonesig (str, sig)
  register char *str;             /* INPUT: string to
                                     analyze */
  register bitmask sig[];         /* OUTPUT: signature for
                                     string */
  /* GLOBAL INPUT: letmask[] and letbit[] */
{
  register int l;                 /* letter number (and loop
                                     counter) */
  int sfreqs [26];                /* frequency distribution
                                     for "str" */
  register bitmask fr;            /* one frequency, shifted
                                     into position */

  makefreqs (str, sfreqs);        /* create a frequency
                                     table for string */

  for (l = 0; l <= lastmask; l++) /* go through all used
                                     bitmasks... */
    sig[l] = 0;                   /* ...initializing their
                                     signature */

  for (l = 0; l < 26; l++)        /* loop through all
                                     letters */
    if (sfreqs [l])               /* does this letter
                                     occur? */
    {                             /* yes: want to add into
                                     its mask */
      fr = ((bitmask) sfreqs [l]) << letbit [l]; /* shift
                                     freq -> position */
      sig [letmask [l]] += fr;    /* and add into the right
                                     mask */
    }                             /* end of adding in letter
                                     frequency */
}                                 /* end of makeonesig() */
```

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What's In a Name?

Anagrams can be surprising. A few of the best I've found by the program are:

Ronald Wilson Reagan = No, darlings, no ERA law.

Strategic Defense Initiative = Face disintegrative entities.

Boston Computer Society = It's our competency boost.

BYTE Magazine = Get by in a maze.

Authors of songs and prose like to hide anagrams for their audiences. When the Doors sang about *Mr. Mojo risin'*, it was an anagram for their lead singer Jim Morrison. In *Lolita*, the character of Vivian Darkbloom is named for the author, Vladimir Nabokov. Finding name anagrams with a program is easy—just use a dictionary of names instead of English words.

If there is no underflow, a pointer to the word is pushed onto the stack. If the signature is exactly zero (i.e., a complete anagram has been found), the function `printanagram` prints the contents of the stack. Otherwise, `findanagrams` calls itself recursively, passing the new set of bits (the remaining letters) and the current word. After printing or recursing, `findanagrams` pops the word from the stack.

Remember that to subtract a bit signature, the program has to loop through one or more masks (the count is in `lastmask`) and check each one. If *any* of the subtractions ANDed with the corresponding underflow mask are nonzero, the word is rejected. If *all* of the results are zero, the word completes an anagram.

This inner loop could be a normal `for` loop, but has been "unrolled" for speed into a C switch statement. Each case is created with the `domask` macro, which subtracts, breaks from the switch if there is an underflow, stores the result, and ORs the result into a flag, which is used to see if any letters remain.

Choosing a Dictionary

This program produces so much output that it's best not to have an on-line *Oxford English Dictionary*. I changed my dictionary to reduce redundancy in the output. For instance, plurals in the dictionary cause nearly-redundant output. My solution was to

continued

Listing 5: *The* `makeuf` *routine, which creates a bit signature in which all the underflow bits are set. The global variable* `uflosig` *contains the resulting underflow mask.*

```
makeuf (freqs, letmask, letbit, letwidth)
  int freqs [];                   /* INPUT: the phrase's
                                     frequency table */
  int letmask [], letbit [], letwidth[];
                                  /* INPUT: mask #,
                                     bit #, field width */
  /* GLOBAL OUTPUT: uflosig */
{
  int l;                          /* letter number */
  int bnum, bwidth;               /* bit number, field
                                     width */

  for (l = 0; l <= MAXMASKS; l++)  /* to start with, clean
                                     out... */
    uflosig [l] = 0;              /* ...each bitmask in the
                                     underflow sig */

  for (l = 0; l < 26; l++)         /* loop through all 26
                                     letters */
    if (freqs [l] != 0)           /* did this letter occur
                                     in the phrase? */
    {                             /* yes: it has a field */
      bnum = letbit [l];          /* get the starting bit
                                     for the field */
      bwidth = letwidth [l];      /* and get the field's
                                     width */

      /* Note that we must use "1L", not just "1" - these
         are longwords. */
      uflosig [letmask [l]] +=    /* take letter's mask from
                                     the sig... */
        (1L << (bnum+bwidth-1)); /* ...and put the
                                     underflow bit in */
    }                             /* end of handling letter
                                     in phrase */
}                                 /* end of makeuf() */
```

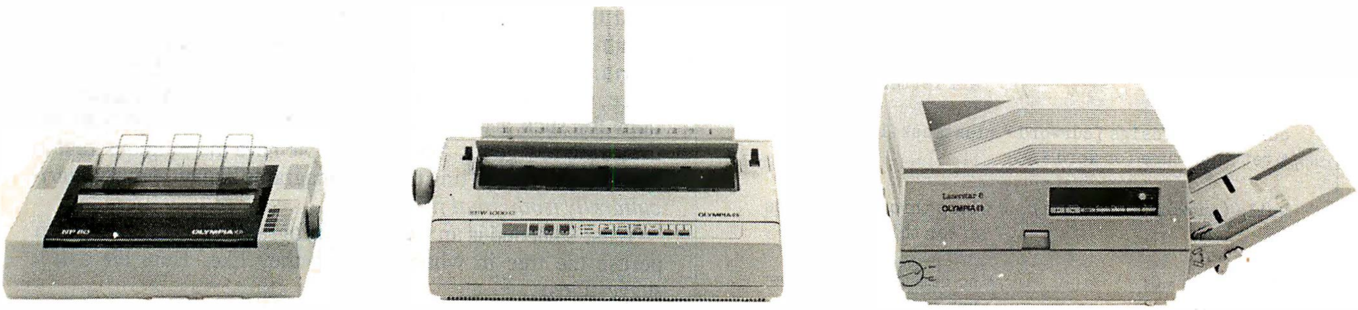
Listing 6: *The recursive* `findanagrams` *function. This routine is passed a node in the search tree and a current word number. The main loop tries all words from the current word to the last one. Each word is subtracted from a copy of the current node. If the result underflows, we skip the word. Otherwise, we push it onto our stack. If the result of the subtraction is exactly an empty signature (all zero), then we've generated an anagram and can print it. Otherwise we recurse, passing the selected word as the current word, and the new signature as the current node. The code to subtract masks is combined with the checks for underflow and zero results in a cascaded "switch" which breaks as soon as it sees an underflow. The cases in the switch are nearly identical, and they are built with the DOMASK macro. If none of the cases detect underflow, the last case falls into processing for a successful subtraction.*

```
#define DOMASK(MASK) {                                   \
                              /* one case of switch */   \
  newmask = curnode [MASK] - cursig [MASK];              \
                              /* subtract from anagram*/ \
  if (newmask & uflosig [MASK])                          \
 /* did the subtraction underflow? */                    \
    break;                                               \
                              /* yes: break switch & do  \
                                 next word          */   \
  newsig [MASK] = newmask;    /* it's OK; store it  */   \
  bitsleft |= newmask;                                   \
                              /* note if there are any   \
                                 bits left          */ }

findanagrams (curword, curnode)
  register int curword;       /* current word number
                                 (used in loop) */
  register bitmask *curnode;  /* bit signature for
                                 current node */
{
  bitsig newsig;              /* the new signature (next
                                 node down) */
```

continued

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```
register bitmask newmask;      /* a single bitmask from
                                  new signature */
register bitmask *cursig;      /* current word's
                                  signature */
register long bitsleft;        /* flag: nonzero if not
                                  all letters used */

cursig = &wordsigs [curword * (lastmask+1)];
/* get signature for word */

while (curword < numwords)     /* loop through all words
                                  after this one */
{
  bitsleft = 0;                /* no remaining bits seen
                                  yet */
  switch (lastmask)            /* check only used masks
                                  in signature */
  {
    case 2: DOMASK(2)          /* handle the 3rd mask, if
                                  there is one */
    case 1: DOMASK(1)          /* handle the 2nd mask, if
                                  there is one */
    case 0: DOMASK(0)          /* handle the 1st mask, if
                                  there is one */

    /* We didn't break, so no underflows occurred. Print
      or recurse. */

     *anaptr++ = wordlist [curword]; /* stack word for
      printing/recursing */
    /* Decide whether the anagram is complete or if we
      must search deeper. */
    if (! bitsleft)            /* no bits left in the
                                  signature? */
      printanagram( );         /* yes: used up all
                                  letters! print it */
    else findanagrams (curword, newsig); /* nope:
                                  climb down to subnode */
    --anaptr;                  /* discard the word from
                                  the stack */
  }                            /* end of switch to
                                  subtract and process */

  curword++;                   /* advance to next word's
                                  number... */
  cursig += (lastmask+1);      /* ...and to next word's
                                  bit signature */
}                              /* end of loop through
                                  words */

}                              /* end of findanagrams( ) */
```

remove most plurals and make *s* a word in the dictionary.

If you sort the dictionary so longest words come first, the first anagrams are more interesting. You can keep the dictionary sorted by this odd rule, or sort the usable words once they're in memory. Sorting each time makes it easy to eliminate duplicate words if you're using more than one dictionary.

If you're working with limited disk space, you might want to pack the dictionary. One easy compression scheme is to remove all letters that a word has in common with its predecessor and replace them with the number of letters removed. Thus, if a dictionary contains *megabaud* followed by *megabyte*, the latter would appear as *5yte*. [Editor's note: *The dictionaries supplied on BIX, BYTEnet, and the Listings disk do this.*]

Dealing with Information Overload

The program can produce staggering amounts of output. Using a dictionary of 25,000 words, *Mike Morton* has 208 anagrams, *Michael Morton* has over 12,000, and *Michael Salomon Morton* has more than 15 *million.* Many phrases produce far too much output to read. A short program has taken anagramming from a painstaking art to a boring problem of information overload.

At the end of his article, Bob Keefer wrote about a seventeenth-century hermit who found over 3000 anagrams for *Ave Maria, gratia plena, Dominus tecum* ("Hail Mary, full of grace, the Lord is with you"). This program would produce billions for such a long phrase, but the amount of drivel would dwarf the few gems. Very few people have the religious zeal to spend their lives sifting through anagrams like *oh, howdy, agriculturally isothermal fife.*

What's needed is an interactive program, allowing humans to peruse the tree in whatever order they like. Here are a few suggestions:

- Nonempty nodes aren't necessarily dead ends. When an anagram search bottoms out with just the letter *n* left, poetic license should let you direct the program to include this as a contraction of *and.*
- The program should show you a list of all possible words from each node. You should be able to climb down to a new node by selecting a word in a way that is quick and intuitive.
- While waiting for user input, the program should explore past the current node, to see if there's an exact anagram below it.
- Remaining letters should be presented graphically, like Scrabble tiles, for you to rearrange using a mouse.
- Words that you'd never want should be removable for a given anagram. In general, you should be able to assign weightings to words, specifying how interesting you think they are.

Using the basic engine described here, it should be possible to do selective, interactively controlled searches instead of exhaustive tree-searches.

Perspective

The evolution of this program demonstrates that you can often speed up long computations such as searches by carefully optimizing your data structures. In this case, using an appropriate representation of text instead of the more obvious character arrays makes a tremendous difference in the time needed to exhaustively search for anagrams.

Having a computer do all the searching, however, doesn't necessarily liberate us from drudgery. This program claims to do all the work, but it actually opens a Pandora's box, producing thousands or millions of lines of output to be read. A high-quality, interactive user interface would tame this technology and make it much more useful. ■

The author would like to thank Evan Morton and James Woods for their advice and encouragement, and Monty Solomon for help in making the program portable.

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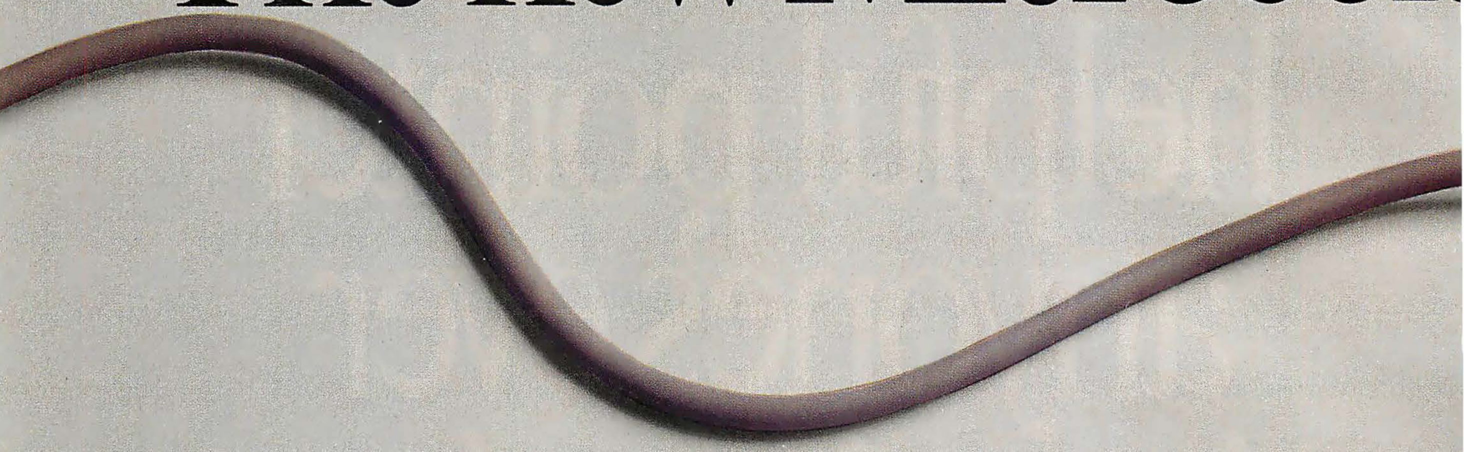
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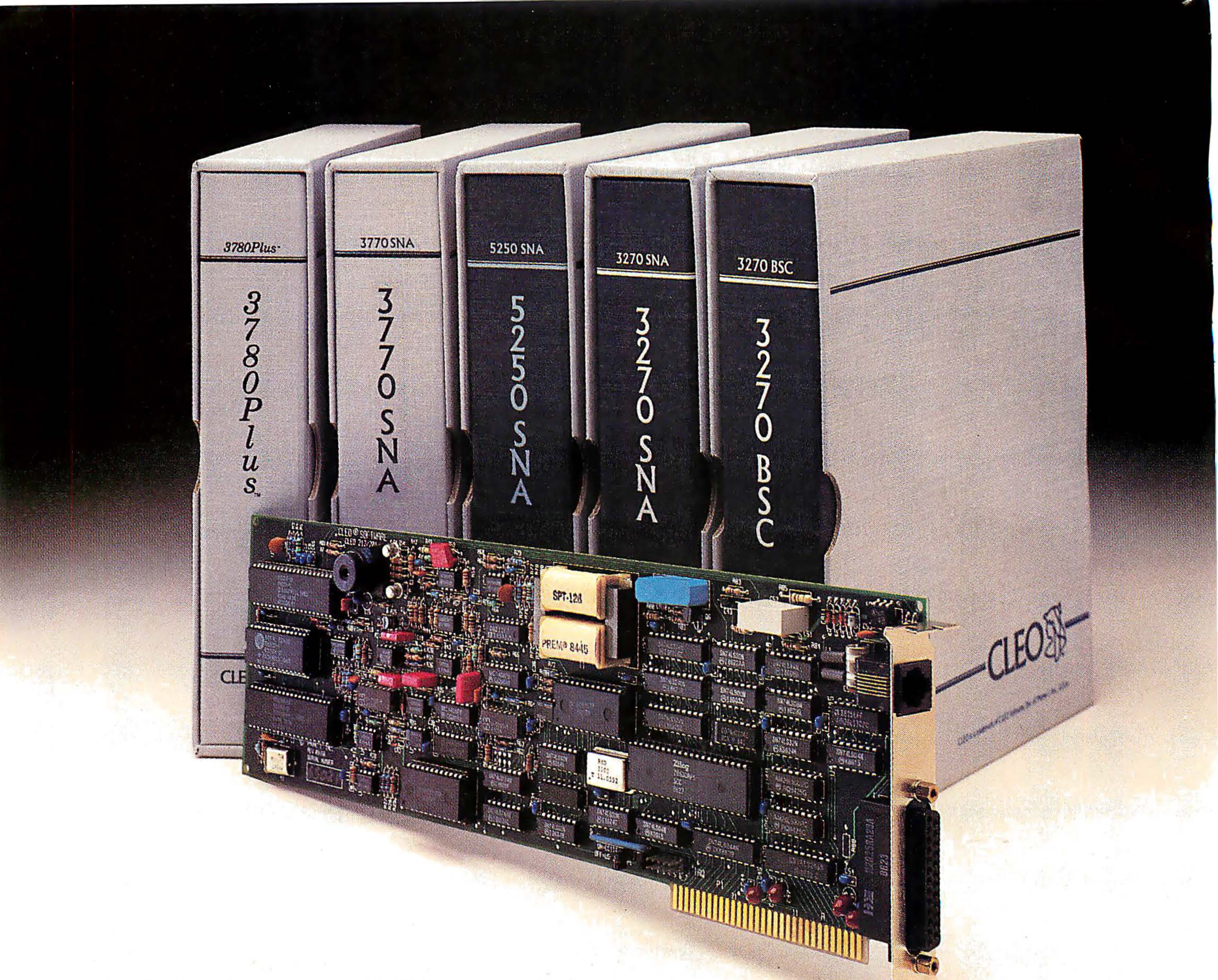
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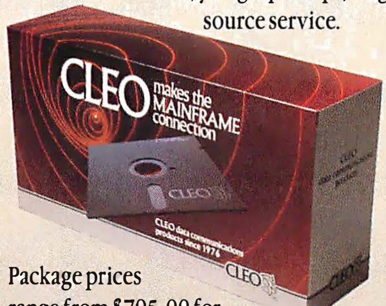
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Jerry LeVan

A Fast CRC

A table-lookup algorithm for calculating the XMODEM cyclic redundancy check algorithm

While developing a terminal-emulator program for my home computer, I discovered that the XMODEM transfer speed, especially at high baud rates, left a lot to be desired. The checksum method was clearly faster than the cyclic redundancy check (CRC) method; the performance of the CRC would not allow effective transfer rates above 500 bytes per second. [Editor's note: *For more information concerning CRC calculation in an XMODEM program, refer to Greg Morse's Programming Project, "Calculating CRCs by Bits and Bytes," in the September 1986 BYTE.*]

I placed a help call to a computer conferencing system and received an intriguing response from Bela Lubkin. The algorithm he suggested for calculating the CRC appeared to be much quicker than the classic bit-shift method. Since it was not at all clear to me how the algorithm worked, I attempted to uncover the mechanics of it. This article is intended to amplify Mr. Lubkin's explanation of how the table-lookup algorithm works.

The Algorithms

Listing 1 contains the three algorithms I will concentrate on. The code in listing 1 consists of three main functions: `compute_crc`, `setup_crc_tables`, and `table_driven_crc`. The function `compute_crc` calculates the CRC byte for a stream of characters. I intend to show that the `table_driven_crc` function computes the same function as `compute_crc`.

The basic operation of the first of the three algorithms is to shift and occasionally exclusive-OR (XOR) the XMODEM generator with the current value of the CRC. The condition for doing the XOR is simple: If a 1 is going to be shifted out of the sign bit, then shift and XOR the old CRC value with the generator. Note that it performs the inner loop exactly eight times. This leads us to a critical observation: Whether or not an XOR is done with the CRC does not depend on the contents of the low byte of the CRC. This is clear because the XOR operation generates no carries, and the shift is performed exactly eight times.

If A, B, and C are 16-bit quantities and we use the + to indicate the bitwise XOR operation, then we know that $A + B = B + A$ and $(A + B) + C = A + (B + C)$. That is, the XOR operation is commutative and associative. This follows from the same properties of the set Z2 (the integers modulo 2).

If we denote the left-shift operator by S (zero shifted into the low bit), then we have the following:

$$(A + B)\,\mathrm{S} = A\mathrm{S} + B\mathrm{S}$$

for any A, B. In other words, the left-shift operator distributes over the XOR operation. For the remainder of this article, I will use the notation Sn to mean n applications of the left-shift operator.

Now let's take a close look at the inner loop of the first algorithm. First, decompose the variable `crc` into `crch` and `crcl`. The variable `crch` is simply the high byte of `crc` with eight zeros appended to make a 16-bit quantity. Similarly, `crcl` is the low byte of `crc` left-extended with zeros to make a 16-bit quantity. Then we have

```
crc = crch + crcl
```

The first pass through the loop yields

```
crc = (crch + crcl)S + P1
```

where `P1` is either 0 or 1021 hexadecimal. (Note: For the remainder of this article, all values will be in hexadecimal unless specified otherwise.) After two iterations we have

```
crc = ((crch + crcl)S + P1)S + P2
crc = crchS2 + crclS2 + P1S + P2
```

where `P2` is either 0 or 1021. Using the facts we arrived at concerning the S and XOR operations, we can write after eight iterations:

```
crc = crchS8 + crclS8 +
  (P1S7 + P2S6 + ... + P8)
```

Again, the `P`s are either 0 or 1021.

Now the term `crchS8` vanishes, so the only question is: How can we calculate the last term? The observation we made earlier tells us that the third term depends only on the initial value of `crch`. This means that we can compute the third term by computing all possible values in the inner loop for `crc` between 0000 and FF00 stepping by 100 and storing the values in array `crc_table`, indexed by values running from 0 to FF. This is exactly the function of the algorithm `setup_crc_tables`.

Thus, the third term can be found by

```
(P1S7 + P2S6 + ... + P8) =
  crc_table [crch >> 8]
```

(Note that the term on the right is C source code.) Remembering that + means XOR, we obtain the relation

continued

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Table 1: *Execution time comparison for the original CRC algorithm (Slow CRC), the author's table-driven version, and a checksum calculation routine. A tick refers to 1/60 second.*

Slow CRC, 100 sectors	120 ticks
Table-driven CRC, 100 sectors	25 ticks
Checksum, 100 sectors	3 ticks

Listing 1: *C source code for the CRC calculation algorithms.*

```
unsigned short crc_table[256];

unsigned short compute_crc(crc,bufptr,len)
register unsigned short crc;
register char *bufptr;
register short len;
{
 register int i;
 while (len--) {
  crc ^= (unsigned short)(*bufptr++)<<8;
  for (i=0; i<8;++i) {
   if (crc & 0X8000)
    crc = (crc<<1) ^ 0X1021;
   else
    crc <<= 1;
  }
 }
 return(crc);
}

setup_crc_tables()
{
 int count;
 char zero;
 zero = 0;
 for (count=0;count<256;count++)
  crc_table[count]=
    compute_crc(count<<8;&zero,1);
}

unsigned short
   table_driven_crc(crc,bufptr,len)
register unsigned short crc;
register unsigned char *bufptr;
register short len;
{
 while (len--)
  crc=
   crc_table[crc>>8^(*bufptr++)]^crc<<8;
 return(crc);
}
```

Table 2: *Effective throughput (see text for definition) of CRC and checksum algorithms during standard 128-byte XMODEM transfers.*

	Baud rate	Effective throughput (bytes/second)
Slow CRC	1200	106
Table CRC	1200	109
Checksum	1200	110
Slow CRC	2400	201
Table CRC	2400	210
Checksum	2400	213
Slow CRC	9600	598
Table CRC	9600	692
Checksum	9600	709
Slow CRC	19,200	770
Table CRC	19,200	1113
Checksum	19,200	1155
Slow CRC	57,600	773
Table CRC	57,600	1172
Checksum	57,600	1263

Table 3: *Same as table 2, except that the XMODEM block size has been increased to 1K byte.*

	Baud rate	Effective throughput (bytes/second)
Slow CRC	2400	210
Table CRC	2400	220
Checksum	2400	222
Slow CRC	9600	628
Table CRC	9600	729
Checksum	9600	745
Slow CRC	19,200	939
Table CRC	19,200	1185
Checksum	19,200	1226
Slow CRC	57,600	994
Table CRC	57,600	1185
Checksum	57,600	1973

```
crc = crc_table [crch >> 8]^
      crcl << 8
```

Substituting this relation into the first algorithm, we easily obtain the third algorithm, which is the `table_driven_crc` function in listing 1.

Measurements

How much faster is the table-lookup CRC technique? I built a 128-byte sector filled with random numbers and applied both the CRC and checksum algorithms 100 times. Table 1 shows the results, which indicate a real savings. However, in a communications program there are many other factors that can slow the transfer. My communications program uses the following optimizations:

- All disk I/O is double-buffered.
- The transmitter sends the body of the XMODEM packet asynchronously and calculates the CRC (or checksum, if you are using that form of XMODEM) while sending the packet. This produces an apparent time to calculate the CRC of almost zero.

Table 2 shows the results of my communications program in actual operation. Note that in this table—as in all subsequent tables—"effective throughput" refers to the quantity

```
PSIZE * NPACKS / TTIME
```

Table 4: *Same as table 2, but now the receiving end immediately acknowledges a received packet.*

	Baud rate	Effective throughput (bytes/second)
Slow CRC	9600	706
Table CRC	9600	707
Checksum	9600	711
Slow CRC	19,200	986
Table CRC	19,200	1155
Checksum	19,200	1161
Slow CRC	57,600	988
Table CRC	57,600	1246
Checksum	57,600	1282

Table 5: *Same as table 2, but using 1K-byte block size and immediate acknowledgment of packet receipt.*

	Baud rate	Effective throughput (bytes/second)
Slow CRC	9600	744
Table CRC	9600	746
Checksum	9600	746
Slow CRC	19,200	1225
Table CRC	19,200	1230
Checksum	19,200	1231
Slow CRC	57,600	1323
Table CRC	57,600	1886
Checksum	57,600	1995

Listing 2: *This is the 68000 assembly language code for replacing the* `table__driven__crc` *function in listing 1.*

```
unsigned short
 asm_table_crc(crc,bufptr,len,table)
 /* D0 has init. vale of crc */
unsigned short crc;
 /* D1 is pointer to buffer */
unsigned char *bufptr;
 /* D2 is number of characters */
short len;
 /* D3 is pointer to crc table */
char *table;
{
#asm
 move.l  d3,a0           ;Get table in A0
 move.l  d1,a1           ;Point to string
 moveq   #0,d1           ;Clear working register
 moveq   #0,d3
 bra.s   @2              ;Start loop
@1 move.b (a1)+,d1       ;Get next char
 move.w  d0,d3           ;Copy current CRC
 lsr.w   #8,d3           ;Position high byte
 eor.w   d1,d3           ;Add in new character
 add.w   d3,d3           ;Convert to index
 move.w  0(a0,d3.w),d3   ;Get table value
 lsl.w   #8,d0           ;Position low byte
 eor.w   d3,d0           ;Compute new CRC
@2 dbra  d2,@1           ;Continue if not done
 #endasm
}
```

where PSIZE is the size of the data packet (not counting XMODEM control characters), NPACKS is the number of packets sent, and TTIME is the number of seconds between the first SOH (start of header) character and the final EOT (end of transmission) character. (The SOH character has a decimal value 01 and is the leading character of a block of data sent during an XMODEM transfer. The EOT character marks the conclusion of an XMODEM transfer session.)

The figures in table 3 show that increasing the XMODEM buffer size to 1024 bytes caused only a modest increase in throughput until the transfer rate reached 57,600 baud. I did not time 1200 baud, because for most systems this would cause excessive time-outs.

Another optimization that you can make on the receiving end is to immediately ACK (acknowledge) a received packet. This allows the transmitter to start sending the next packet while the receiver is calculating the CRC of the previous packet. With this scheme, a retransmit request can detect (but not correct) errors. This allows another improvement at high speeds (see table 4).

Increasing the buffer size to 1024 and using the quick ACK method yielded the figures that appear in table 5.

Your Mileage May Vary

One should take timing tests with a grain of salt. However, it is clear that the table-lookup algorithm stays closer to the checksum method than the standard bit-shift algorithm. The efficiency and speed of compiled code can vary greatly from machine to machine. I made these tests with two directly connected machines.

I have found that CompuServe typically yields an effective throughput of about 60 to 80 bytes per second at 1200 baud. Genie typically yields 70 to 80 bytes per second at that rate. My neighborhood VAX 785 lets me run with an effective throughput of 103 to 105 bytes per second (all with XMODEM).

In my first attempt at XMODEM, I used a function call for processing each character in the CRC-calculation loop. In addition, I did not overlap the CRC calculation with transmission of the packet. This was a mistake; I could not get an effective throughput of more than 500 characters per second (even with 4K-byte buffers) at any speed! The bottom line is that it takes a number of optimizations to speed up a complex process.

Finally, if you have a Macintosh, you can replace the routine `table_driven_crc` with the Mac C 68000 assembly language routine in listing 2. Some timing tests I have done indicate that the assembler is about twice as fast as the high-level routine and about 4½ times slower than a checksum version written in assembly language. In fact, `asm_table_crc` took 13 ticks for 100 sectors of 128 bytes. ■

Thanks to Bela Lubkin for his help.

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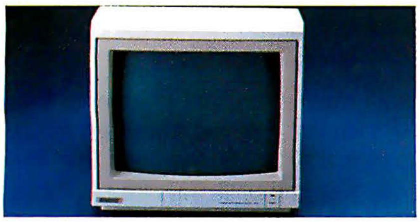
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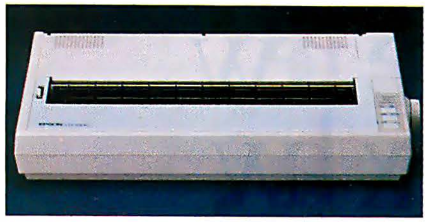
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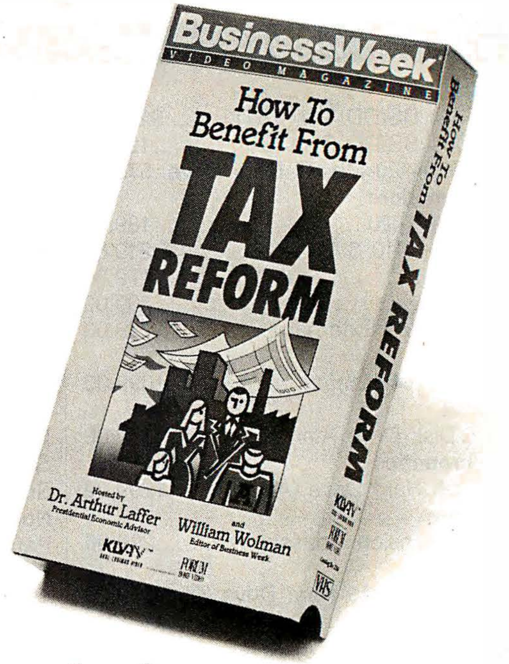
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BY-I

Isaac Malitz

The Turing Machine

The TM represents a profound analysis of the nature of machines, information, and mechanical processes

The modern computer is an elaboration of a simple device known as the Turing Machine (TM) and invented in the 1930s by the British mathematician, logician, and cryptographer Alan Turing (see reference 1). The TM is so simple that you can describe it on a single sheet of paper, yet it is capable of achieving the complexity of a modern computer.

The TM represents a profound analysis of the nature of machines, information, and mechanical processes. It is a minimal computer with a tiny instruction set, yet you can program it to achieve great complexity. Conceived by Turing as a "universal machine"—a device capable of emulating any kind of mechanical process—the TM incorporates many of the fundamental characteristics of all computers. (For a discussion of the differences between TMs and present-day computers, see the text box "The TM vs. Today's Computer" on page 346.)

The Decision Problem

The design of modern computers has been influenced deeply by Turing's work. When he invented the TM, he was not actually trying to build a computer. Rather, he was working on a complex problem in pure mathematics: the decision problem.

The decision problem is concerned with the possibilities of using mechanical methods to find solutions to mathematical problems. A great deal of mathematical activity amounts to the mechanical manipulation of symbols according to certain specific rules—a kind of game with the aim of reaching a certain outcome. If mathematics can be reduced to a game, it might be possible to devise purely mechanical procedures for exploring all aspects of the game and eventually for determining answers to all mathematical problems.

In the late nineteenth century, mathematicians succeeded in reducing almost all of mathematics to a specific game—now known as *first-order predicate logic*—that seems to capture most of the logical structure underlying mathematics. If you could completely master this game, you would be able to answer most questions in mathematics.

First-order predicate logic is a completely precise game that consists of manipulating strings of symbols according to a series of simple rules. Most mathematical problems can be represented as questions about what outcomes are possible from certain initial positions in this game. The decision problem is this: Is there a mechanical method for determining, for all possible positions and all possible outcomes in first-order predicate logic, whether a given outcome can be reached from a given position? If the answer is yes, mathematical problems can be solved by training an army of clerks, or building a machine, to carry out appropriate search procedures. If the answer is no, certain kinds of mathematical problems cannot be conquered by purely mechanistic approaches. Such problems would either be unsolvable in some sense or would require some nonmechanistic faculty (perhaps intuition, inspiration, or luck) for their solution.

Turing's Analysis

Turing showed that the answer to the decision problem is no; that no mechanical procedure is adequate to evaluate all possible outcomes of all positions in the game of first-order predicate logic. (For a detailed presentation of Turing's solution to the decision problem, see reference 2.) To prove this, he first had to develop a precise definition of "mechanical procedure." The TM embodies this definition (see reference 3).

A mechanical procedure is a step-by-step, completely defined, unambiguous procedure for manipulating symbols. Its steps should be sufficiently precise to be carried out by a competent, unassisted clerk with no special mathematical abilities. For each step, the action is precisely specified; at no point are choices or chance operations allowed. You can easily specify mechanical procedures for adding a column of numbers, performing long division, computing the square root of a number, or determining which of two strings of symbols precedes the other alphabetically. Therefore, in principle, you ought to be able to use a machine to implement equivalent procedures.

The clerk reads and writes symbols at various locations on a sheet of paper of unlimited size that has been divided into squares. Each square may hold one symbol, or it may be blank. The alphabet of symbols available for the clerk's use is finite. At any particular moment, the clerk is either observing a few symbols at a certain location, writing a symbol at a certain location, or shifting attention from one location to another.

The clerk's behavior at any moment is determined by the symbols observed and by a finite number of momentary states of mind. Let's divide time into a series of discrete moments that are short enough that no more than one symbol can be written in a single moment. Suppose that at a certain moment, the clerk is observing some symbols. There is a limit s to the number of symbols that can be observed at one time. If the clerk ever needs to observe more than s symbols, a series of successive moments must be used. If the clerk is shifting attention from one location to another, there is also a limit d to the distance (the number of squares) that attention can travel in one moment.

Thus, at one moment in a certain state of mind, the clerk ob-

continued

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The TM vs. Today's Computer

The major differences between the Turing Machine and a modern computer or microprocessor are:

• *Memory addressing:* The TM has limited memory-access capabilities. All the data processed by a TM is on a tape. From one operation to the next, the TM can access only adjacent squares on that tape. It lacks a built-in memory-addressing ability.
• *Commands separated from memory:* In modern computers, commands usually reside in memory, the same storage used by all other kinds of data. Commands in a TM reside in a state table rather than on the tape (memory).
• *Peculiar command structure:* Essentially, there is only one kind of command available with a TM. Unlike a modern computer, where commands are ordered sequentially in the form of a program, commands in a TM are organized into a state table.

Listing A: *A section of code representing the odd/even checker Turing Machine in BASIC.*

```
2000 IF X THEN b, R, GOTO 2010
2001 IF b THEN E, Halt
2010 IF X THEN b, R, GOTO 2000
2011 IF b THEN O, Halt
```

Bridging the Gap

With imaginative programming, you can implement some memory-addressing capabilities on a TM. For instance, you might be able to implement a routine that could read three binary numbers (called *p*, *q*, and *r*) encoded at a certain location on the tape; and copy *p* symbols, starting at location *q* (i.e., the *q*th square from the left on the tape), to the area starting at location *r*, replacing whatever was previously there.

You could overcome the problem of commands being separate from memory if you could write a state table onto a tape and have the TM execute it. Turing showed how to design a Universal Turing Machine (UTM) to emulate the behavior of any TM whose state table appears first on the tape. You can code the state table in a manner similar to (although not exactly the same as) the DATA statements in listing 1 on page 354. For instance, the following tape might represent the odd/even checker:

```
+XbsR+bEhh+sXbR+sbOhh@XXXXXbbb...
```

The first part of the tape

```
+XbsR+bEhh+sXbR+sbOhh
```

represents the four entries in the state table—each entry is separated by a +. The h symbol stands for Halt. A string of s symbols stand for a state—for example, one stands for state 1, two would stand for state 2, no s symbols stands for state 0. Compare this to the state table in table 3. The remainder of the tape, beginning with the @ symbol, @XXXXXbbb..., represents the DATA section of the tape. When the UTM finishes operating, the tape would look like this:

```
+XbsR+bEhh+sXbR+sbOhh@bbbbObbb
```

The first part of the tape representing the state table is unchanged. The data section of the tape is operated on as before. Because of its ability to operate from a state table that is encoded on its tape, the UTM qualifies as a primitive stored-program computer. The state table for a UTM is quite complex; for a detailed discussion, see reference 4.

Although the TM's peculiar command structure accepts just one kind of command, you can build up a library of routines that are equivalent to the machine-language commands of modern microprocessors. Once this is accomplished, programming a TM is much like programming a microprocessor (except for the inefficiency of program execution).

The concept of a state table is not essential to a TM. You could replace state tables with a conventional BASIC-like programming language, with an instruction set consisting of one command. A state table could be expressed as a conventional program, consisting of a sequence of these commands. Each line of the program would be numbered in accordance with BASIC syntax.

For instance, the program in Listing A represents the odd/even checker. Each command is of the same form: `IF` *`symbol`* `THEN` *`new-symbol`*`, R/L, GOTO` *`line-number`*. Each line corresponds to one entry in the state table: lines 2000 and 2001 correspond to the entries for state 0; lines 2010 and 2011 are for state 1.

serves not more than *s* symbols at a certain location on the paper. Depending on the symbols (and the state of mind), one of the following responses occurs: The clerk writes a symbol in a certain square, shifts attention to a new location on the paper not more than *d* squares away, or changes to a different state of mind. At each moment, the symbols observed and the state of mind from the previous moment determine what actions the clerk will perform and what the next state of mind will be.

You could build a simple machine that is capable of processing symbols in this manner. A number of formulations for the machine are possible, depending on the number of symbols allowed, the number of states of mind allowed, the shape of the paper, and various values for *s* and *d*. Turing investigated a variety of formulations and discovered that many of them are equivalent. (For instance, you can replace a sheet of paper that is many possible locations wide with a paper tape only one location wide without limiting the capabilities of the machine. You can also set the parameters *s* and *d* both to 1 without limiting the TM's capabilities.) Turing chose an especially simple and elegant formulation, which is now known as the Turing Machine, as the focus of his mathematical researches.

The TM is a model, or idealization, of the imaginary clerk's behavior. It is capable of being in a finite number of states, and at any moment its attention is focused on a small area of "paper." Depending on what state it is in, and what it "reads" on the paper, the TM responds by writing a symbol, moving to another location, or switching into a different state.

A TM is a symbol-processing machine. It processes symbols on a tape that is infinite in length but only one square wide. Each square may hold one symbol or be blank. Only a finite alphabet of symbols is allowed; in this case, the uppercase letters *A* through *Z*, the special symbols @ and %, and a blank, symbolized by the lowercase letter b. The TM has a read/write head that can determine what symbol is in a square and write a symbol into a square. When a symbol is written into a square, it replaces whatever was there. The read/write head can move to the right or to the left along the tape, one square at a time.

A TM can also exist in a finite number of states: state 0, state 1, and so on. At any particular moment, a TM is in one particu-

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lar state, scanning one particular square on the tape. Depending on that state and the symbol detected, the TM writes a certain symbol into that square, moves the read/write head one square to the right or left, switches into a different state, or halts.

An Odd/Even Checker

This TM examines a string of Xs and determines whether the string is odd or even in length. The string starts at the left side of the tape, and, following the last X, the remainder of the tape consists of blank squares (i.e., XXXXXbbbb...). The TM for this problem has two states: state 0 for an even number of Xs, and state 1 for an odd number of Xs. The TM starts at the left side of the tape and moves to the right, replacing each X with a blank, or b. It begins in state 0, and each time it moves to the right, it alternates between state 0 and state 1, indicating whether it has seen an odd or even number of Xs so far. When it reaches the end of the string, the TM records an E if the number of Xs is even; that is, if it is in state 0, or an O if odd, in state 1. Table 1 gives an exact description, called a state table, of this TM:

- If the TM is in state 0 and finds an X, it replaces the X with a b, switches into state 1, and moves one square to the right.
- If the TM is in state 1 and finds an X, it replaces the X with a b, switches into state 0, and moves one square to the right.
- If it finds a b in state 0, it replaces the b with an E and halts.
- If it finds a b in state 1, it replaces the b with an O and halts.

Table 2 traces the action of the odd/even checker TM on a tape containing five Xs followed by blanks. If the tape initially has an odd number of Xs, the final tape is blank except for a single O. If the tape initially contains an even number of Xs, the final tape is blank except for an E.

Tabulating Votes

Let's look at a tape containing the votes for two election candidates. It contains an X for every vote received by candidate X, and a Y for each one received by candidate Y. To program a TM to determine which candidate won the election, the strategy is to make a number of passes through the tape. With each pass, the TM erases one X and one Y, reducing both the number of Xs and the number of Ys by one. Eventually, the TM will be unable to find both an X and a Y to erase. If only Xs remain on the tape, then candidate X won; if only Ys are left, then candidate Y won; if neither Xs nor Ys remain on the tape, then the vote was a tie.

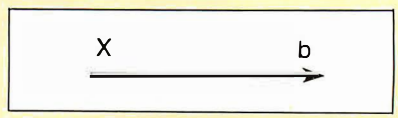
This strategy requires one special symbol to mark the beginning of the tape and another one to mark the end of the original

continued

Diagramming a TM

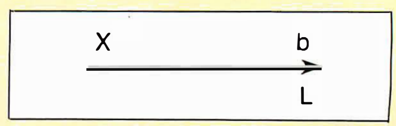
Figure A shows a method for depicting the state table of any TM. Each state is represented by a circle with a state number in it. Inside each circle is an R or an L. This is the default direction in which that state operates. For example, state 2 usually moves to the right after operating on a square, so the default direction is R.

There are arrows running between certain circles. These describe how particular states operate on certain symbols. For instance, between S0 and S1 you see:



This signifies that if the TM reads an X in state 0, it replaces the X with a b and switches to state 1. The read/write head moves in the default direction unless indicated otherwise on the arrow.

There will be times when you'll need to override the default direction. For example, between S2 and S3 you see:



This signifies that if the TM reads an X in state 2, it replaces it with a b, switches to state 3, and moves to the left. The L on the arrow signifies "move left," which overrides the default direction for state 2. If there is no new symbol at the end of an arrow, the old symbol in the square remains in effect.

Many state/symbol combinations are not shown on the diagram. If one occurs, the symbol is unchanged, the read/write head moves in the default direction, and the TM remains in the same state. For instance, the combination of S2 and Y is not shown. Therefore, if the TM sees a Y in state 2, it leaves the Y unchanged, moves in the default direction R, and stays in the same state.

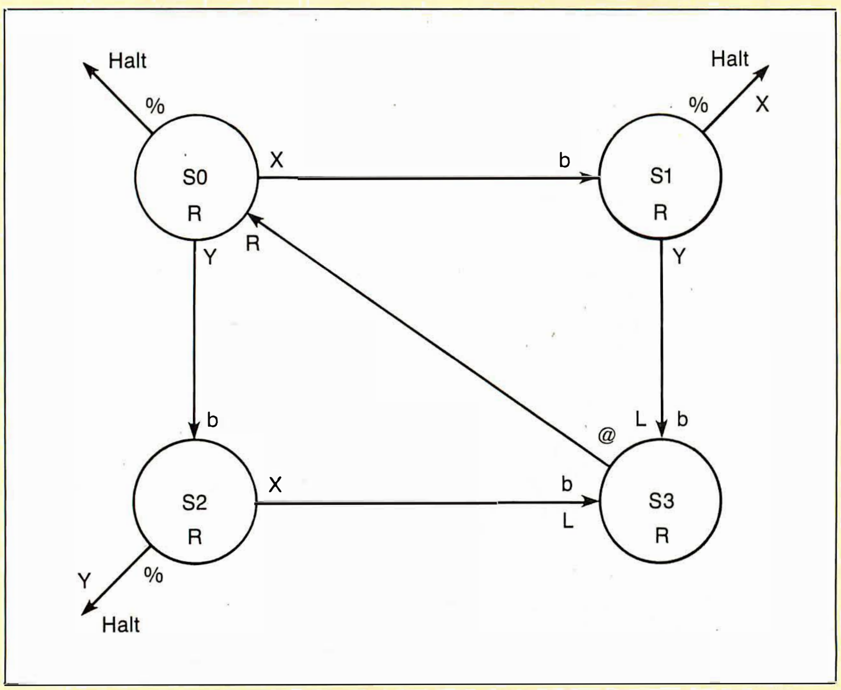
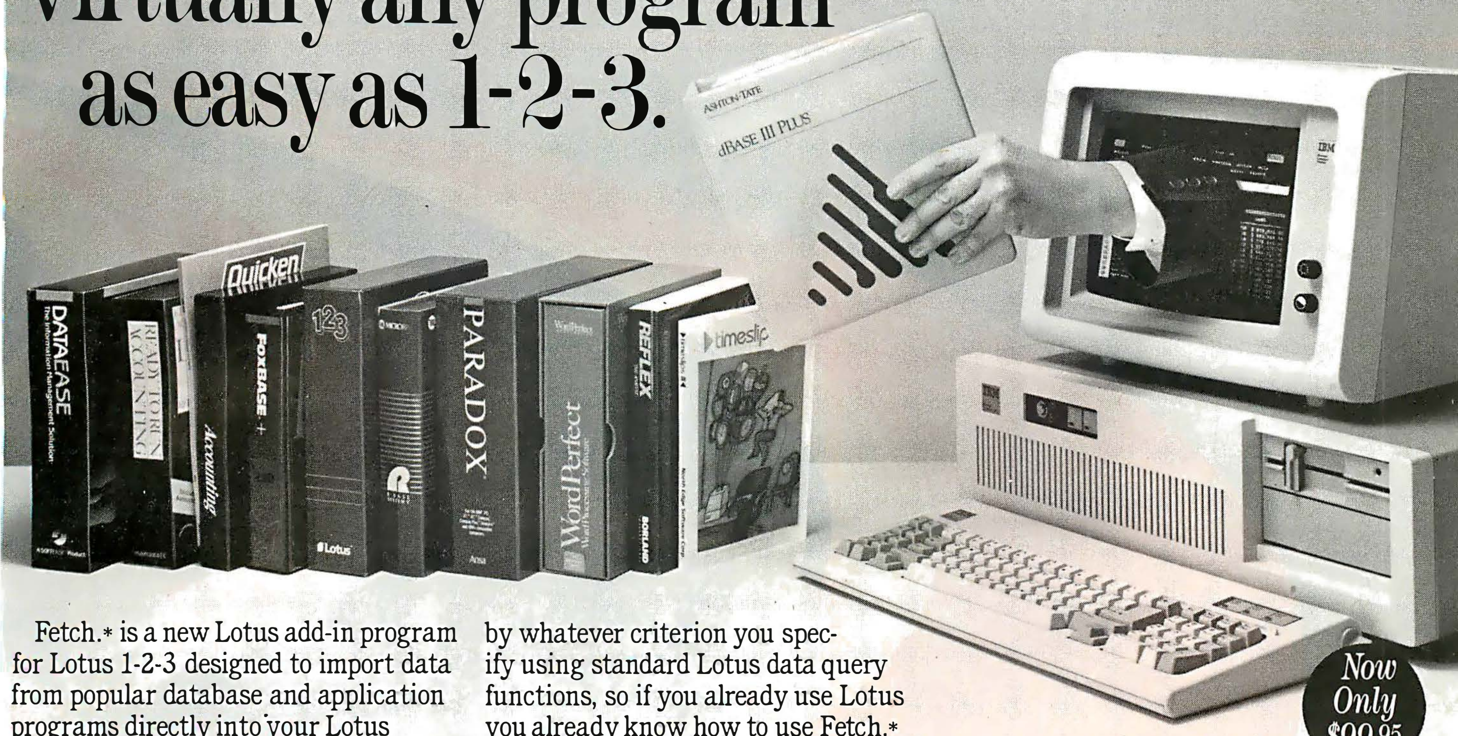


Figure A: *A means of diagramming a Turing Machine, using the vote-tabulating TM as a base.*

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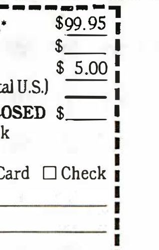
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Table 1: *The state table for the odd/even checker TM.*

State	Symbol scanned	New symbol	New state	Move
0	X	b	1	Right
0	b	E	Halt	
1	X	b	0	Right
1	b	O	Halt	

Table 2: *The sequence of operations performed by the odd/even checker TM.*

Tape and position of read/write head	State of TM
XXXXXbbbbb.....	0
bXXXXbbbbb.....	1
bbXXXbbbbb.....	0
bbbXXbbbbb.....	1
bbbbXbbbbb.....	0
bbbbbbbbbb.....	1
bbbbbObbbb.....	Halt

Table 3: *The state table for the vote-tabulating TM.*

State	Symbol scanned	New symbol	New state	Move
0	@	@	0	Right
0	X	b	1	Right
0	Y	b	2	Right
0	b	b	0	Right
0	%	%	Halt	
1	@	(Never occurs)		
1	X	X	1	Right
1	Y	b	3	Left
1	b	b	1	Right
1	%	X	Halt	
2	@	(Never occurs)		
2	X	b	3	Left
2	Y	Y	2	Right
2	b	b	2	Right
2	%	Y	Halt	
3	@	@	0	Right
3	X	X	3	Left
3	Y	Y	3	Left
3	b	b	3	Left
3	%	(Never occurs)		

string of Xs and Ys. Let's use the @ symbol to mark the beginning and the % symbol to mark the end. A typical tape might look like: @XXYXYYY%....... Table 3 contains the state table for this vote-tabulating TM and reads as follows:

- The TM begins in state 0 and moves to the right.
- If it finds an X first, it switches into state 1 and changes the X to a b. Then it looks for a Y and remains in state 1 for the rest of that pass.
- If the TM finds a Y first, it switches into state 2 and changes the Y to a b. Then it looks for an X and remains in state 2 for the rest of that pass.
- If the TM finds (and erases) both an X and a Y in a single pass, it then changes into state 3, reverses direction, and moves to the left until it finds the @.
- If during any pass the TM finds the %, it has completed its task. If it is in state 1, it changes the % to an X for the unmatched X it has already found. Likewise, if the TM is in state 2, it changes the % to a Y. Then it halts.

Table 4 shows the sequence of operations for this example. After processing, only a Y remains on the tape. Besides determining whether there are more Xs or Ys on the tape, this TM also shows how many more votes the winner has than the loser. Thus, it performs a primitive kind of subtraction. This calculation is painfully tedious. You can program a TM to process this problem much more efficiently, but the programming is more complex. TMs tend to be inefficient and difficult to program. (For a description of how to diagram a TM using this example as its base, see the text box "Diagramming a TM" on page 348.)

Simulating a TM in BASIC

TM1.BAS, the IBM PC BASIC program in listing 1, can simulate any TM. (It is easily adaptable into most other dialects of BASIC; however, note its use of `MID$` and `INPUT`, which do not apply to all dialects.) [Editor's note: *TM1.BAS is available on disk, in print, and on BIX; see the insert card following page 384 for details. Listings are also available on BYTEnet; see page 4.*] In the program, the configuration of the tape is given in the variable `T$`. The state table and the tape correspond to the odd/even checker. By changing the `DATA` statements and the value of `T$`, you can imitate any state table and tape that you want.

When you run this program, you will see the output of the TM's operation one step at a time. Below each display of the current tape's contents will be an arrow showing the current location of the read/write head, a number giving the current state of the TM, and the next entry to be retrieved from the state table (see table 5). Press Return to advance from one step to the next.

TM1.BAS is a straightforward simulation of a TM. The state table is represented in `DATA` statements beginning in line 2000: `0X-b1R` means that if the TM is in state 0 and finds an X, it should replace the X with a b, switch into state 1, and move one square to the right. The dash is only punctuation to improve readability, but a period within a `DATA` unit means halt.

Lines 200 through 220 initialize the variables `T$`, `S$`, and `P`, which are used according to the conventions of TM programming. `T$` contains the tape and is initialized in line 200. In this example, the tape is limited to 40 squares, but you could adapt the program for a longer tape. `S$` tracks the current state of the TM. It starts with a value of 0 and is initialized in line 210. In this example, the only values it can have are 0 and 1, which signify state 0 and state 1, respectively. `P` tracks the position of the read/write head on the tape. It starts with a value of 1 and then increases or decreases as the read/write head moves to the right or the left, respectively.

Lines 400 through 900 create a loop that does the main work of the program. Lines 400 and 410 display the tape's current configuration and the read/write head's current position. Line 420 checks to see if the TM is ready to halt.

Lines 500 through 520 retrieve the appropriate entry, the one that corresponds to the current state, and the contents of the current square from the state table. (These two values are stored in

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the variable M$.) For example, if the TM is in state 1 and the symbol being scanned is X, then S$ is 1, MID$(T$,P,1) is X, and M$ is 1X. Lines 510 and 520 sequentially search the state table to match M$. Line 520 is a loop that examines each DATA unit one at a time, starting from the beginning. When the program finds a match, it exits the loop with the appropriate DATA unit in the variable R$. (If the program does not find a match, you get an error message indicating that the DATA statements, and thus the information within the state table, have been exhausted without finding the appropriate entry.)

Line 600 displays the current state and the appropriate entry from the state table. Line 610 is a dummy INPUT statement. Its effect is to freeze program execution until you press Return. This lets you observe the TM's execution, step by step.

Lines 800 through 840 examine the information in R$ (the entry from the state table) and execute the appropriate response. Line 800 writes the appropriate new symbol on the current square. Lines 820 and 830 determine whether the read/write head should advance to the left or to the right. Line 840 deter-

continued

Table 4: *The sequence of operations performed by the vote-tabulating TM.*

Tape and position of read/write head	State of TM	Tape and position of read/write head	State of TM	Tape and position of read/write head	State of TM
@XYYYXYX%	0	@bbbYbYX%	3	@bbbbbYb%	3
@XYYYXYX%	0	@bbbYbYX%	3	@bbbbbYb%	3
@bYYYXYX%	1	@bbbYbYX%	0	@bbbbbYb%	3
@bbYYXYX%	3	@bbbYbYX%	0	@bbbbbYb%	0
@bbYYXYX%	3	@bbbYbYX%	0	@bbbbbYb%	0
@bbYYXYX%	0	@bbbYbYX%	0	@bbbbbYb%	0
@bbYYXYX%	0	@bbbbbYX%	2	@bbbbbYb%	0
@bbYYXYX%	0	@bbbbbYX%	2	@bbbbbYb%	0
@bbbYXYX%	2	@bbbbbYX%	2	@bbbbbYb%	0
@bbbYXYX%	2	@bbbbbYb%	3	@bbbbbbb%	2
@bbbYbYX%	3	@bbbbbYb%	3	@bbbbbbb%	2
@bbbYbYX%	3	@bbbbbYb%	3	@bbbbbbbY	Halt
@bbbYbYX%	3	@bbbbbYb%	3		

Listing 1: *TM1.BAS, a program to simulate any TM, in IBM PC BASIC.*

```
1     REM TM1 - EASY TM SIMULATOR
199   REM TAPE
200   T$="XXXXXbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb"
210   S$="0":REM STARTING STATE = 0
220   P=1:REM STARTING POSITION ON TAPE = 1
400   PRINT:PRINT T$
410   PRINT TAB(P);"^":REM POSITION OF READ-WRITE HEAD
420   IF S$ = "." THEN END
499   REM L.500 - 520 DO STATE TABLE LOOKUP
500   M$= S$ + MID$(T$,P,1)
510   RESTORE
520   READ R$:IF MID$(R$,1,2) <> M$ THEN 520
600   PRINT:PRINT S$,R$
610   INPUT "",X
799   REM REWRITE SYMBOL ON TAPE
800   MID$(T$,P,1)=MID$(R$,4,1)
819   REM MOVE LEFT ON TAPE
820   IF MID$(R$,6,1)="L" THEN P=P-1
829   REM MOVE RIGHT ON TAPE
830   IF MID$(R$,6,1)="R" THEN P=P+1
840   S$=MID$(R$,5,1):REM DETERMINE NEW STATE
900   GOTO 400
2000  DATA "0X-b1R","0b-E.." :REM STATE 0
2010  DATA "1X-b0R","1b-0.." :REM STATE 1
```

Table 5: *The output of TM1.BAS, showing the contents of the tape, the location of the TM, the state, and the next entry in the state table at each step.*

```
XXXXXbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
^

0                 0X-b1R
bXXXXbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
 ^

1                 1X-b0R
bbXXXbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
  ^

0                 0X-b1R
bbbXXbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
   ^

1                 1X-b0R
bbbbXbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
    ^

0                 0X-b1R
bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
     ^

1                 1b-0..
bbbbb0bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
     ^
```

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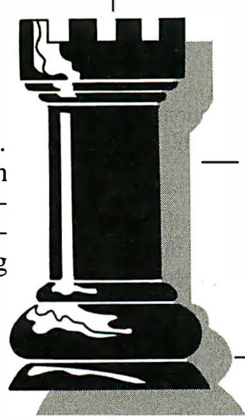
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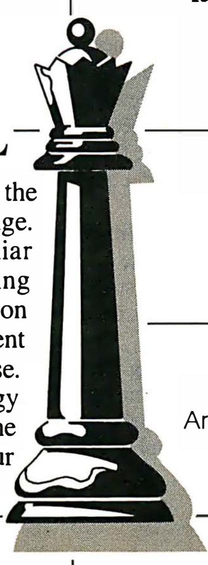
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Table 6: *The sequence of operations performed by the addition TM in calculating the sum of 2 + 3.*

```
Tape and position of                         State
read/write head                              of TM

XXbXXXbbbbbbbbbbbbbbb                         0
^
XXbXXXbbbbbbbbbbbbbbb                         0
 ^
XXbXXXbbbbbbbbbbbbbbb                         0
  ^
XXbXXXbbbbbbbbbbbbbbb                         1
   ^
XXbbXXbbbbbbbbbbbbbbb                         2
  ^
XXXbXXbbbbbbbbbbbbbbb                         0
   ^
XXXbXXbbbbbbbbbbbbbbb                         1
    ^
XXXbbXbbbbbbbbbbbbbbb                         2
   ^
XXXXbXbbbbbbbbbbbbbbb                         0
    ^
XXXXbXbbbbbbbbbbbbbbb                         1
     ^
XXXXbbbbbbbbbbbbbbbbb                         2
    ^
XXXXXbbbbbbbbbbbbbbbb                         0
     ^
XXXXXbbbbbbbbbbbbbbbb                         1
      ^
XXXXXbbbbbbbbbbbbbbbb                         Halt
      ^
```

mines the new state, if there is one. Line 900 sends the program back to the beginning of the processing loop.

The DATA statements that express the state table are at the end of the program. Convention dictates putting the DATA units for state 0 at line 2000, those for state 1 at line 2010, state 2 at line 2020, and so on. Convention also dictates omitting from the state table any state-symbol combinations that never occur.

An Addition TM

This TM computes the sum of two numbers, each represented by a string of Xs of the appropriate length and separated from each other by a single blank square, by concatenation. The DATA

continued

Listing 2: *The* DATA *statements required to concatenate two strings separated by a single blank.*

```
2000  DATA "0b-b1R","0X-X0R"
2010  DATA "1b-b..","1X-b2L"
2020  DATA "2b-X0R"
```

Listing 3: *The* DATA *statements required to connect two strings separated by more than one blank.*

```
2000  DATA "0X-X0R","0b-b1R"
2010  DATA "1b-b1R","1X-b2L","1%-%.."
2020  DATA "2b-b2L","2X-X3R"
2030  DATA "3b-X1R"
```

A Reader Contest

Now we'd like to try something a little different. The following three problems will be described in skeleton form. We invite you to submit the state tables and tape necessary to solve them in the form of DATA statements and line 200 replacements to be inserted into TM1.BAS. Solutions must accept and correctly calculate a variety of inputs and not be specific to only one individual case; for example, a multiplication must work for $x \times y$, not just for 2×2.

A complete specification for a TM consists of a list of the symbols in its alphabet and a set of state descriptions that specify for each state what the TM does in response to each symbol in the alphabet. Let's assume that a TM always begins in state 0, with its read/write head positioned on the tape's leftmost square.

Modifications to TM1.BAS or other programs for simulating a TM will be read with interest but are not part of the contest. Send your solutions to Turing Machine Contest, c/o BYTE Editorial, One Phoenix Mill Lane, Peterborough, NH 03458, or via BIXmail to "editors." We will publish the most interesting solutions in a future issue and award modest prizes for solutions we judge to be outstanding. Have fun!

Multiplication

First, create a TM that will multiply two variables, both greater than zero. The first number is represented by a string of Ps, the second by a string of Qs, and the product by a string of Ts. The operations consist of marking Ps and Qs in an appropriate pattern, and gradually adding Ts to the tape as you go. You may use other characters as intermediate steps in the processing, and as many nonduplicate states as you wish. You must begin processing in state 0. The final tape does not need to contain only T and b symbols; the final number of Ts must, however, equal exactly P times Q.

Copying a String

Create a TM that makes a copy of a variable string of Xs and Ys with a single blank between the original string and its copy. The symbols from the original string should be copied one at a time, beginning with the leftmost symbol. Somehow, the TM must remember what symbol it is copying as it travels from the first string to the second string. One way to accomplish this is to use certain states to signify X and other states to signify Y. This technique is a common way of remembering small amounts of information in a TM. (The method of replacing symbols with temporary symbols is another way of remembering.) You may use states as befit your method, but you must begin in state 0. The final tape must contain the original string, followed by one blank, followed by the copy of the original string, followed by blanks.

Calculating a Remainder

Then, create a TM to calculate the remainder of a variable number after division; for example, the remainder of 63 MOD 5 is 3. The tape must begin with a @, followed by a string of Ps representing the divisor, followed by a string of Xs representing the dividend, followed by a %. The TM will express the the remainder as a string of Qs. For example, 5 MOD 2 would be expressed on the tape as @PPXXXXX%bbbbbbbbbbb. The number of Qs on the tape after operations are complete is the answer. In this case, the TM should show that 5 MOD 2 is 1.

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statements in listing 2 represent the state table for the TM. If the initial tape configuration is XXbXXXbbbbbbbbbbbbbb (the Xs represent the numbers 2 and 3), then the sequence of operations in table 6 will occur. It also shows the state for each operation. The concept is fairly easy; you can see how it works by examining table 6 in detail. In the final tape configuration, the string of five Xs represents the number 5 (the answer to 2 + 3). To run this example in TM1.BAS, you need to set line 200 to `200 T$="XXbXXXbbbbbbbbbbbbbb"` and replace the `DATA` statements with those in listing 2.

This TM will add two strings properly only if they are separated by exactly one blank square. You can set up a TM so that it will add strings that are separated by more than one blank square. If you insert the `DATA` structure in listing 3 into TM1.BAS, you can have any number of blank squares between the two strings. However, immediately to the right of the second string of Xs you must have a % symbol. To try it, set line 200 to `200 T$="XXbbXXX%bbbbbbbbbbbb"`. You can adapt this TM so you don't have to mark the end of the second string with a special symbol, but the programming is complex. Basically, you must add extra states so that the TM knows when it is looking at blank squares between the two strings and when it is looking at a blank square to the right of both strings. For some TMs that you can program, see the text box "A Reader Contest" on page 356.

Elegant But Inefficient

The TM is an elegant machine. However, programming it is like writing programs in machine language, but often an order of magnitude more difficult. Its fundamental operations are so primitive that you need a large number of operations to accomplish anything interesting. Its limited memory access is difficult to deal with, but you can use special symbols, markers, codes, and conventions. You can also use states as a means of recalling small amounts of information. In addition, you can implement common kinds of logical structures into TMs such as conditional branching, loops, and nested loops.

Difficult and inefficient though it is, the TM provides an interesting exercise in the step-by-step detailed thought processes used by the original developers of computers. Each operation must be broken down into its most elemental steps. The very level of detailed thought required is a lesson for those of us who have been spoiled by high-level languages.

The influence of the TM has been mainly intellectual—as a point of reference, a standard, and a body of ideas for designers of practical computer systems. Turing's 1936 paper is one of the great characterizations of the essence of a computer. The TM established a set of minimum requirements for a universal computing system and suggested some specific architectures for the design of actual computers. It also established Alan Turing as a major figure in the foundation of computer science. ■

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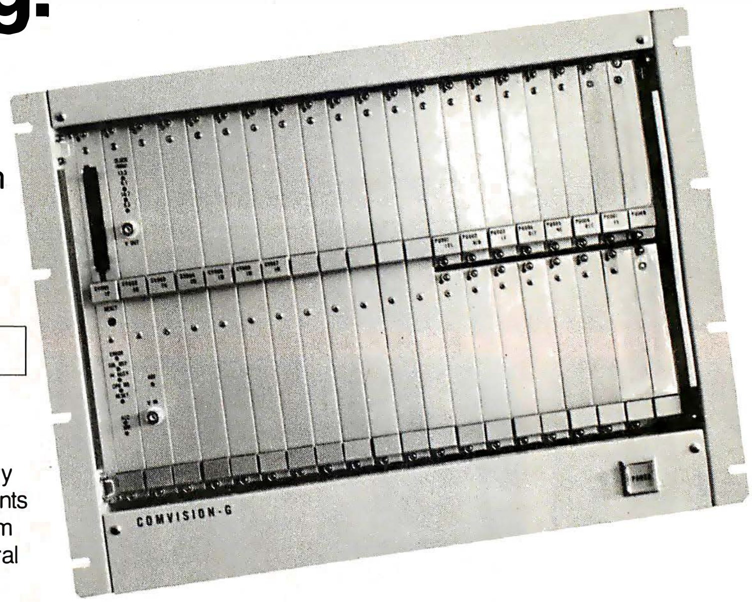
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• Processing speed example

Processing	Speed *1
Spatial filter Average filter (3 x 3) SOBEL differentiator Laplacian (3 x 3) Other coefficients (3 x 3)	 216m/sec. (24m/sec.) *2 300m/sec. (48m/sec.) 120m/sec. (24m/sec.) 218m/sec. (24m/sec.)
Operation between images (AND, OR, EXCLUSIVE-OR, ADD, SUBTRACT, etc.)	24m/sec.
Gray level histogram	33m/sec.
Gray level conversion Histogram conversion Binary conversion γ(gamma) correction Enhancement Typical gray level extraction Conversion into any gray level	12m/sec.
Labeling	200m/sec. *3
Logical filter Fatting Shrinking Removal isolated point Line thinning (1-subcycle)	24m/sec.
Run length conversion	32m/sec.

*1 Processing speed applies to 512 x 512 image size.
*2 The bracketed values are obtained when an optional spatial filter board is used.
*3 During the latter 100m/sec. in the labeling process when only one μPD7281 is operating, the other 3 processors may be assigned other processing tasks.

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COMVISION-G has an innovative tool that provides flow graph capability similar to CAD techniques for the NECμPD7281.
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• Specifications

Processer	μPD7281 (NEC data flow processor) x 4 Clock 10MHz
Image memory	512 x 512 (8-bit) x 4 planes
Data memory	1.5M byte
Hardware processing capabilities (High-speed pipeline processor unit)	Spatial filter, Gray level conversion, Binary conversion, Operation between images, Gray level histogram, Logical filter, Run length conversion, Window extraction (255 locations), Typical point extraction Processing speed 12 ~ 33m/sec. (512 x 512)

*Specifications are subject to change without notice.

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A C Interface

A C header file that provides easy access to the ANSI device services through C function calls

Most, if not all, of the big-name C compiler packages do not provide even the most rudimentary screen, graphics, or cursor-control capability. You can't even clear the screen!

To solve this problem, I've made a C header file, ANSISYS.C (see listing 1), that provides easy access to the ANSI device services—such as cursor control and keyboard translation—all through C function calls. These function calls are actually implemented as macros.

Like any C program, each of the macros can itself become a building block for a still larger macro. Note the evolution of `WINDOW` from the `DRAW` and `FILL` macros when you examine the code.

Refer to the *MS-DOS Reference Manual* and the ANSI.SYS device driver commands for the original control sequences that are made into C macros here.

Run the ANSIDEMO.EXE program for a demonstration of these macros and C programming tools in action. There are demos for setting screen characteristics, text attributes, extended keyboard functions, and the use of arrow keys, to name a few. For example, the Set Display/Color demo allows you to select the display's foreground color, background color, and text attributes, such as blinking or underline. [Editor's note: *For monochrome monitors, the underline attribute works as described, but on a color monitor this attribute renders the text as blue. This is a characteristic of the adapter card. See the* Peter Norton Programmer's Guide to the IBM PC, *Microsoft Press, 1985, page 81. Results may also vary depending on your choice of video adapter card and monitor.*] I've supplied the C code in the file ANSIDEMO.C that provides you with source code examples.

To use these macros, simply include the ANSISYS.C header file in your program. The ANSI.SYS file that came with your MS-DOS 2.x operating system must be present on your boot disk, and the file CONFIG.SYS on the boot disk must specify

continued

Don F. Ridgway owns Custom Business Programs (119 Plantation Ct., Suite D, Tampa, FL 33617), specializing in C and compiled database applications. He is also founder of the Tampa dBASE User's Group.

Listing 1: *The ANSISYS.C header file.*

```
/** ansisys.c
*
*   ANSISYS.C
*   (C) Copyright 1985 Don F. Ridgway
*   All rights reserved.
*   This program may be copied for
*   personal, nonprofit use only.
*
*   Written, compiled and tested in Microsoft C
*   version 2.03, and Lattice C versions 2.15 and 3.00, under
*   PC-DOS 2.1 and 3.1 on a Compaq and an IBM PC AT, both with 640K bytes
*   of RAM and an 8087, using the Turbo Pascal 3.0 screen editor.
*
*   Please refer to the MS-DOS/PC-DOS Reference Manual and the
*   ANSI.SYS device driver commands for the original commands
*   and control sequences that are here made into C macros.
*
*   Refer to the IBM Technical Reference Manual or to the
*   appendix of the BASIC version 2 Reference for the ASCII
*   character codes and the extended keyboard function codes.
*
*   Remember that C is case-sensitive, so be sure and
*   reference the following macros with CAPITAL LETTERS.
*
**/
```

continued

```
#define BEEP                              printf("\007")
  /* 800-Mz tone for 1/4 second -- same as PRINT CHR$(7) */
#define CLEARSCREEN                       printf("\033[2J")
#define CLS                               CLEARSCREEN
  /* clears the screen and positions cursor at top left corner */
  /* "\033" is octal for "Escape" or ASCII decimal 27 (CHR$(27)) */
  /* "Escape-[" is the lead-in for the ANSI.SYS code routines */
#define CURSPOS(x,y)                      printf("\033[%u;%uH",(x),(y))
#define XY(x,y)                           CURSPOS(x,y)
  /* positions cursor at x = row, y = column */
#define EOL                               printf("\033[K")
  /* erases to end of line, including cursor position */
  /* NOTE: error in DOS documentation has 'K' lowercase */
#define XYEOL(x,y)                        printf("\033[%u;%uH\033[K",(x),(y))
  /* positions cursor at x,y then erases to end of line */
#define XYWHERE              printf("\033[6n");scanf("%*1c%2d%*1c%2d%*2c",&row,&col)
    /* requests cursor position, device driver answers row,col--declare int */
#define CURSUP(x)                         printf("\033[%uA",(x))
#define CURSDWN(x)                        printf("\033[%uB",(x))
    /* cursor up or down x-number of lines */
#define CURSFWD(y)                        printf("\033[%uC",(y))
#define CURSBCK(y)                        printf("\033[%uD",(y))
    /* cursor forward (right) or backward (left) y-number of spaces */
#define SAVCURS                           printf("\033[s")
#define RECALLCURS                        printf("\033[u")
    /* cursor position is saved for later recall via RECALLCURS */
#define CPR(x,y,z)                        printf("\033[%u;%uH%c",(x),(y),(z))
#define XYCHAR(x,y,z)                     CPR(x,y,z)
    /* position cursor at x,y and print char z (using ASCII code) */
#define XCTRPRINTF(x,str)                 printf("\033[%u;%uH%s",(x),((80-(strlen(str)-1))/2),str)
    /* on row x, center (and printf) the string str (in double quotes) */
#define CURSPOSPRTF(x,y,str)              printf("\033[%u;%uH%s",(x),(y),str)
#define XYPRINTF(x,y,str)                 CURSPOSPRTF(x,y,str)
    /* at position x,y printf the string str (in double quotes) */
#define XKREAD(x)                         x=0;x=bdos(1);if (bdos(11)) x=bdos(8)+128
    /* extended code keyboard read, reads function keys, arrow keys, etc. */
  /* NOTE: bdos ( ) doesn't work this way in Microsoft C 3.0 and 4.0 */
#define XKREADE(x)                        x=0;x=bdos(1);if (bdos(11)) x=bdos(1)+128
    /* same as XKREAD( ), except this one echoes the input on the screen */
#define CHKBRK                            if (key==196) break
    /* if F10 key was pressed, break out of loop */
#define SETSCREEN(a)                      printf("\033[=%uh",a)
    /* set screen graphics mode */
/* 0=40x25 monochrome,1=40x25 color,2=80x25 mono,3=80x25 color,          */
/* 4=320x200 color,5=320x200 mono,6=640x200 mono,7=enable word wrap.     */
#define RESETSCREEN(a)                    printf("\033[=%ul",a)
  /* reset screen graphics mode */
  /* the attributes are same as SETSCREEN(a) except 7=disables word wrap */
#define SETDISPLAY(a,b,c)                 printf("\033[%u;%u;%um",a,b,c)
  /* set screen display attributes and colors = (a,b,c) any order:       */
  /* 0 = default, 1 = high intensity, 4 = underline,                     */
  /* 5=blinking,7=inverse,8=invisible (black-on-black),30=foreground
black,                                                                   */
  /* 31=fore red,32=fore green,33=fore yellow,34=fore blue,35=fore magenta, */
  /* 36=fore cyan,37=fore white,40=background black,41=back red,42=back
green,                                                                   */
  /* 43=back yellow,44=back blue,45=back magenta,46=back cyan,47=back white. */
#define HLON                              SETDISPLAY(0,0,1)
  /* set high light (high intensity) on */
#define BLON                              SETDISPLAY(0,0,5)
  /* set blinking on */
#define HLOFF                             SETDISPLAY(0,0,0)
#define BLOFF                             HLOFF
  /* set high intensity, blink (and all other display attributes) to off */
#define PROMPT(x,y,cc)                    SETDISPLAY(0,0,7);printf("\033[%u;%uH",(x),(y));\
                                           cc=getchar();SETDISPLAY(0,0,0)
  /* at position x,y read inverse prompt for input cc */
#define XKPROMPT(x,y,z)                   HLON;XY((x),(y));printf("\b");XKREAD(z);HLOFF
  /* at position x,y read highlighted prompt for input z */
#define WINDOW(a,b,c,d,e,f)               DRAW(a,b,c,d,f);FILL(a+1,b+2,c-1,d-2,e)
  /* a rectangle determined by upper left-hand corner coordinates, */
```

continued

```
  /* row1 = a, col1 = b, and lower right-hand corner coordinates, */
  /* row2 = c, col2 = d, is filled with extended graphics character */
  /* ASCII decimal code e, and the border is ASCII decimal code f */
#define WINDOW2(a,b,c,d,e,f)                DRAW(a,b,c,d,f);DRAW(a+1,b+1,c-1,d-1,255);\
                                             FILL(a+1,b+2,c-1,d-2,e)
  /* same as WINDOW(a,b,c,d,e,f) except use this one to overwrite other */
  /* drawings because this one fills empty spaces with blanks */
  /* ------------------------------------------------------------- */
  /** DRAW(row1,col1,row2,col2,icon)                               */
  /*                                                               */
  /*  can be rectangle, vertical line, horizontal line or point!   */
  /*                                                               */
  /*  row1,col1=upper left-hand corner of border                   */
  /*  row2,col2=lower right-hand corner                            */
  /*  icon=ASCII decimal number of character want border made of   */
  /*                                                               */
  /*   (Note: Error-trapping is up to you in calling program,      */
  /*          e.g., [0<=row<=24], [0<=col<=80], graphics mode,     */
  /*          etc.)                                                */
  /*                                                               */
  /* Dbl Lines=205;Sngl Line=196;Dark=176;Medium=177;Light=178     */
  /* White=219;Blank=255;Sunshine=15;Music notes=14;Asterisks=42   */
  /* Happy Face=1,2;Hearts=3;Diamonds=4;Clubs=5;Spades=6;Beeps=7   */
  /* ------------------------------------------------------------- */
  /**/

  DRAW(row1,col1,row2,col2,icon)
  int row1, col1, row2, col2, icon;
  {
    int hlen,hlen2,vlen,r,c,hzl,vtl,ulc,llc,urc,lrc;

    hlen=hlen2=col2-col1;
    vlen=row2-row1;
if (hlen<0 || vlen<0) BEEP;                  /* audibly alert possible input error */

if (hlen<=0 && vlen<=0)                      /* then it's a point or a corner */
  {
  CPR(row1,col1,icon);
  return(0);
  }

if (vlen<=0)                                 /* then it's a horizontal line */
  {
  CURSPOS(row1,col1);
  while(hlen--)
    printf("%c",icon);
    return(0);
  }

switch (icon)
  {
  case 196:                                  /* for single line border */
  case 218:
             hzl=196;vtl=179;ulc=218;llc=192;urc=191;lrc=217;
             break;
  case 201:                                  /* for double line border */
  case 205:
             hzl=205;vtl=186;ulc=201;llc=200;urc=187;lrc=188;
             break;
  case 213:                                  /* for double top, single side */
             hzl=205;vtl=179;ulc=213;llc=212;urc=184;lrc=190;
             break;
  default:                                   /* for same char all around */
             hzl=vtl=ulc=llc=urc=lrc=icon;
  }

if (hlen<=0)                                 /* it's a vertical line -- use vtl from above */
  {
  CURSPOS(row1,col1);
  for (r=1;r<=hlen;r++)
```

continued



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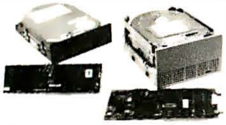
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```
      CPR(r,col1,vtl);
      return(0);
    }
                                             /* if it's fallen through this far, it's a rectangle */
   CURSPOS(row1,col1);
   while(hlen--)                             /* print horizintal icon top row, left to right */
     printf("%c",hzl);
   CPR(row1,col2,urc);                       /* print upper right-hand corner */
   for (r=row1+1;r<row2;r++)                 /* print vertical right-hand column, top to bottom */
     CPR(r,col2,vtl);
   CPR(row2,col2,lrc);                       /* print lower right-hand corner */
   CURSPOS(row2,col2-1);
   while(hlen2--)                            /* print horizontal bottom row, right to left */
     printf("%c\b\b",hzl);                   /* one forward, two back (NOTE: this is slow) */
   CPR(row2,col1,llc);                       /* print lower left-hand corner */
   for (r=row2-1;r>row1;r--)                 /* print vertical left-hand column, bottom to top */
     CPR(r,col1,vtl);
   CPR(row1,col1,ulc);                       /* print upper left-hand corner to complete object */
   return(0);
}                                            /* end DRAW( ) function */
/* ---------------------------------------------------------------------------------- */
/** FILL(row1,col1,row2,col2,icon)                                                    */
/*                                                                                    */
/* can be "window," vertical line, horizontal line or point!                         */
/*                                                                                    */
/* row1,col1=upper left-hand corner of area to be filled                              */
/* row2,col2=lower right-hand corner                                                  */
/* icon=ASCII decimal number of character want area filled with                       */
/*                                                                                    */
/*  (Note: Error-trapping is up to you in calling program,                            */
/*         e.g., [0<=row<=24], [0<=col<=80], graphics mode,                           */
/*         etc.                                                                       */
/*                                                                                    */
/* Dbl Lines=205;Sngl Line=196;Dark=176;Medium=177;Light=178                          */
/* White=219;Blank=255;Sunshine=15;Music notes=14;Asterisks=42                        */
/* Happy Face=1,2;Hearts=3;Diamonds=4;Clubs=5;Spades=6;Beeps=7                        */
/* ---------------------------------------------------------------------------------- */
/**/
FILL(row1,col1,row2,col2,icon)
int row1,col1,row2,col2,icon;
{
   int hlen,hlen2,vlen,r,c;

   hlen=hlen2=col2-col1;
   vlen=row2-row1;
   if (hlen<0 || vlen<0) BEEP;               /* audibly alert possible input error */

   for (r=row1;r<=row2;r++)
     {
     hlen=hlen2+1;
     CURSPOS(r,col1);
       {
       while(hlen--)
         printf("%c",icon);
       }
     }
   return(0);
}                                            /* end FILL( ) function */
```

that the ANSI driver is to be loaded (DEVICE = ANSI.SYS). The C language is case-sensitive, so remember to reference the macros with capital letters. I've tested ANSISYS.C and ANSIDEMO.C with Microsoft C version 2.03 and Lattice C version 2.15 and 3.00 under PC-DOS 3.1 on a Compaq with 640K bytes of RAM.

[Editor's note: *The files ANSISYS.C and ANSIDEMO.C are available on disk, in print, and on BIX. See the insert card following page 384 for details. Listings are also available on BYTEnet. See page 4. These three files also have been donated to and are available from the C User's Group, P.O. Box 97, McPherson, KS 67460.*] ■

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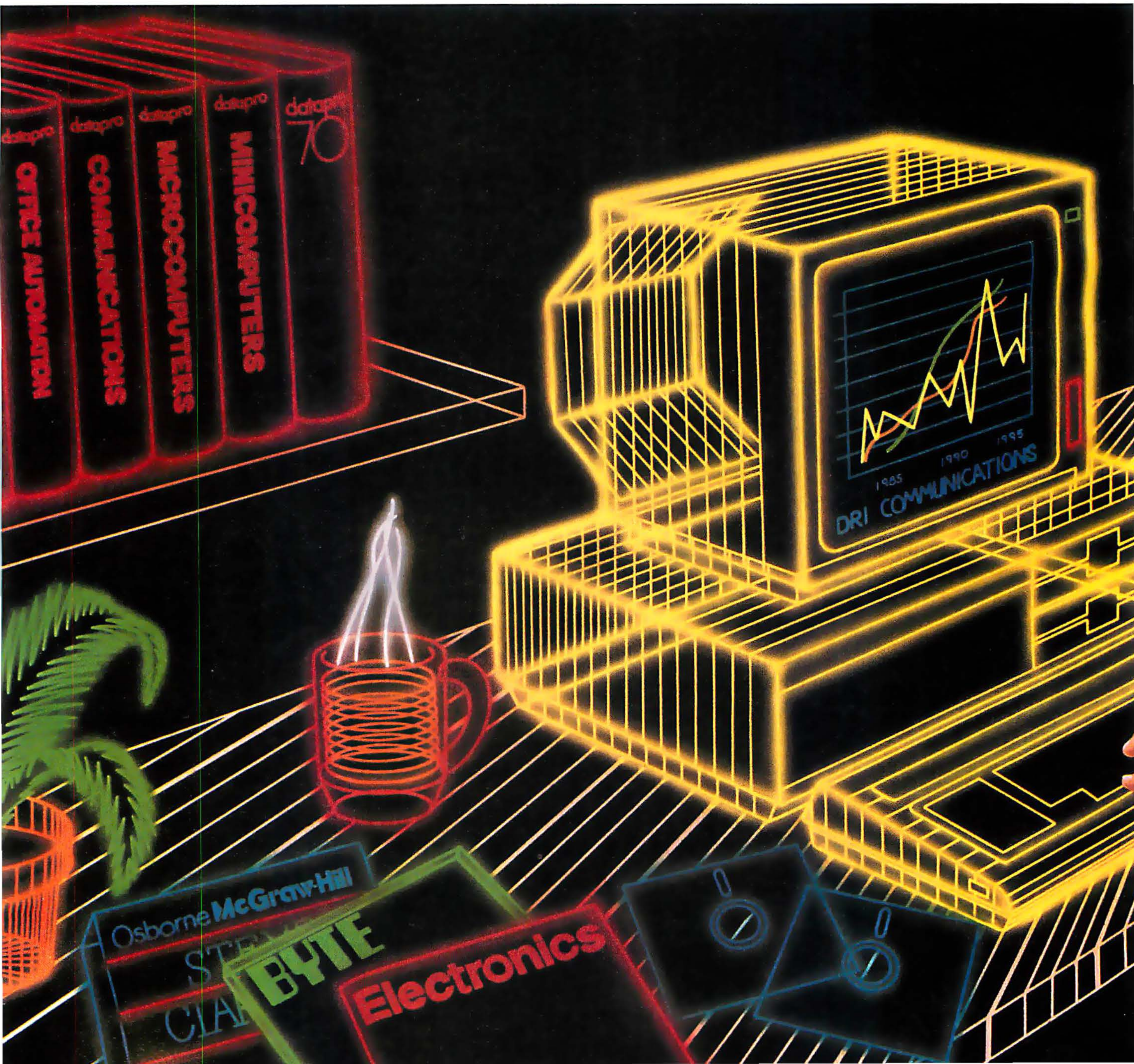
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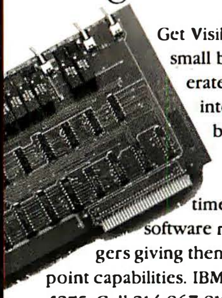
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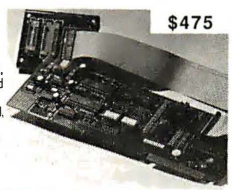
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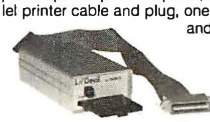
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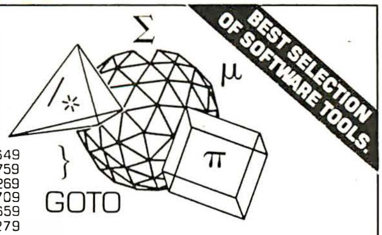
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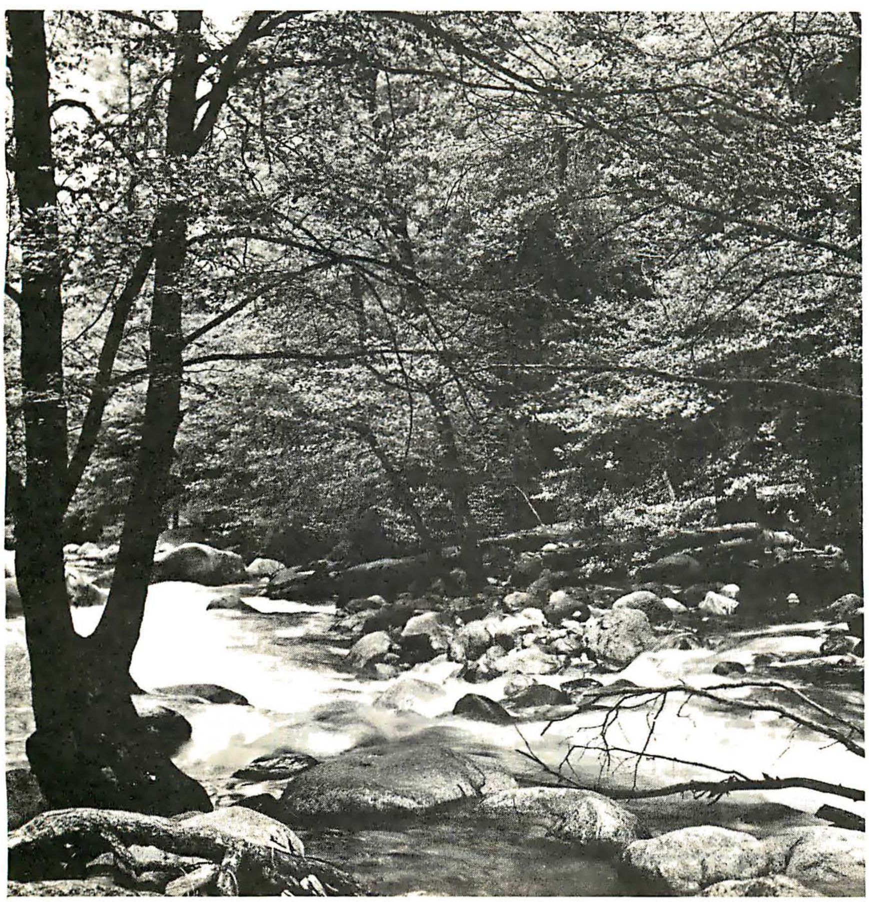
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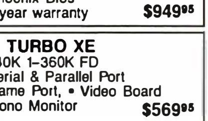
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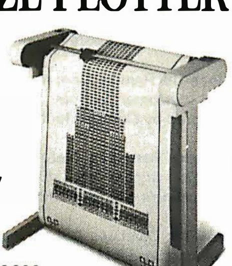
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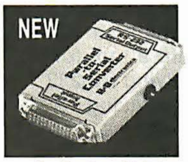
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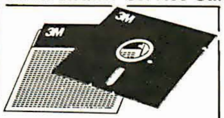
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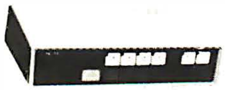
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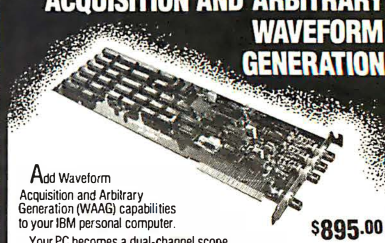
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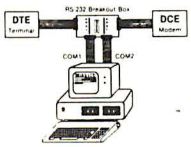
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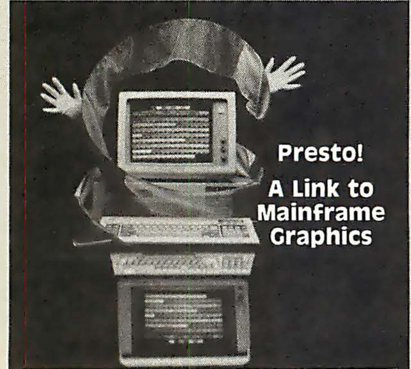
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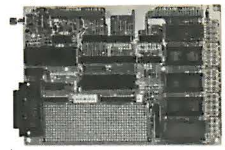
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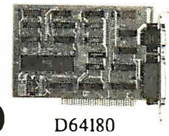
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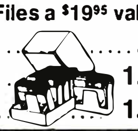
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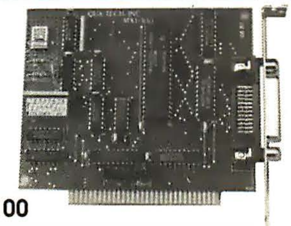
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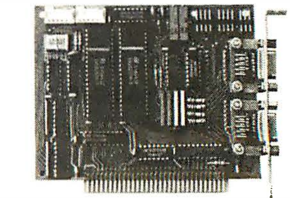
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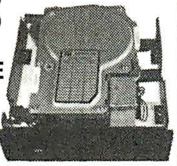
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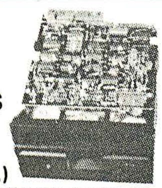
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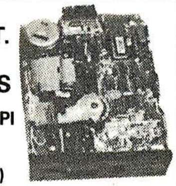
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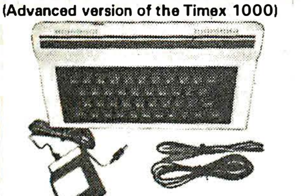
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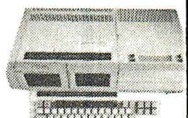
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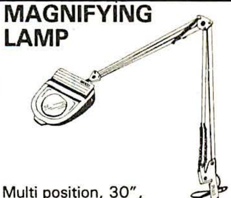
(Less printer)
No wiring necessary (just plugs together). Hook-up diagram incl. Includes: Keyboard, 1 cassette digital data drive, 2 game controllers, power supply, & one cassette. Can run CP/M, has built-in word processor. Item #7410
Complete – **$99.00**

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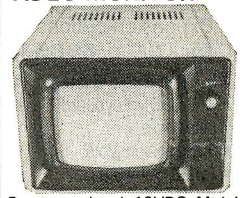
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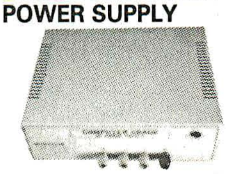
Power regulated, 12VDC. Mtd. in plastic cabinet, w/brightness control knob. Mfr — Sperry
OA Dim.: 8"W x 8"H x 8¾"deep
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ADAM 5¼" DISK DRIVE



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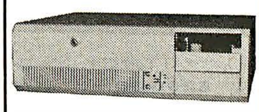
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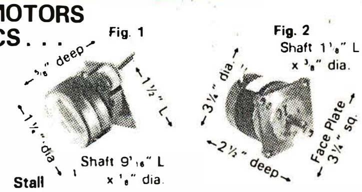
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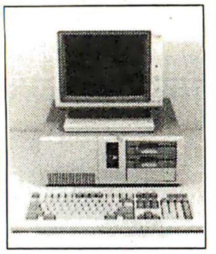
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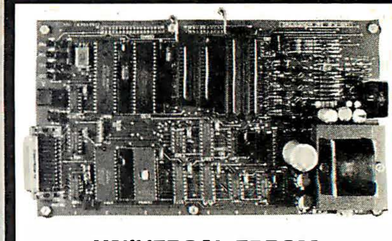
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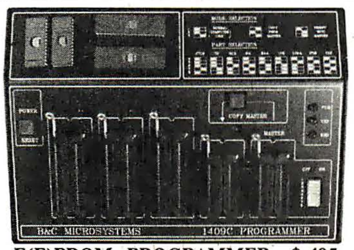


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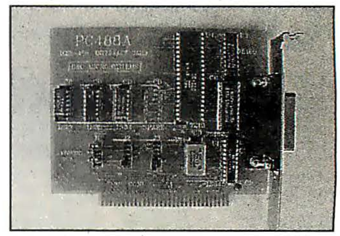
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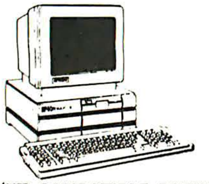
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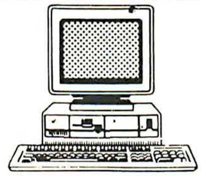


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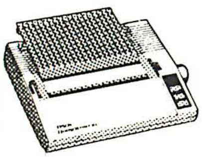
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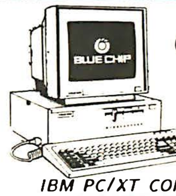
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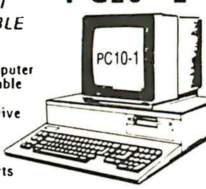
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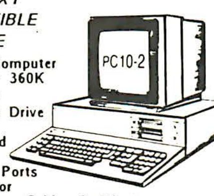
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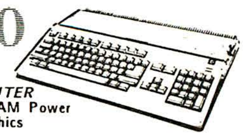
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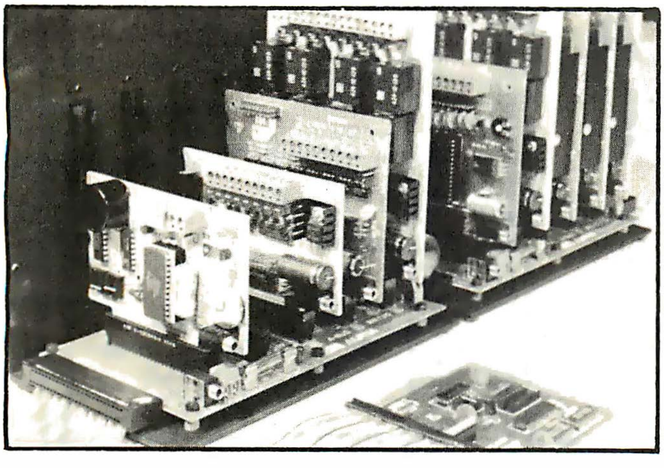
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About the A-BUS:

- All the A-BUS cards are very easy to use with any language that can read or write to a Port or Memory. In BASIC, use INP and OUT (or PEEK and POKE with Apples and Tandy Color Computers)
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- A-BUS cards are shipped with power supplies (except PD-123) and detailed manuals (including schematics and programming examples).

Relay Card — RE-140: $129
Includes eight industrial relays, (3 amp contacts, SPST) individually controlled and latched. 8 LED's show status. Easy to use (OUT or POKE in BASIC). Card address is jumper selectable.

Reed Relay Card — RE-156: $99
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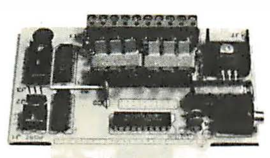
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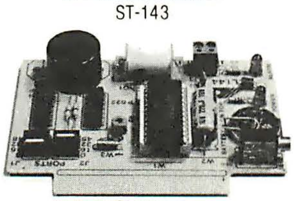
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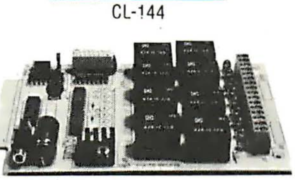
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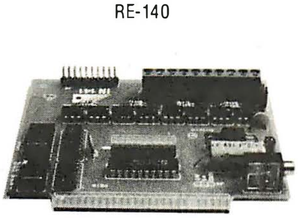
ST-143



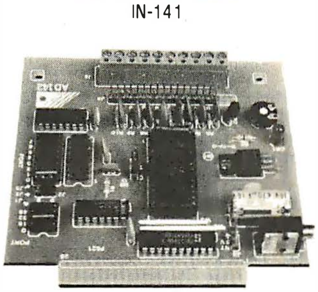
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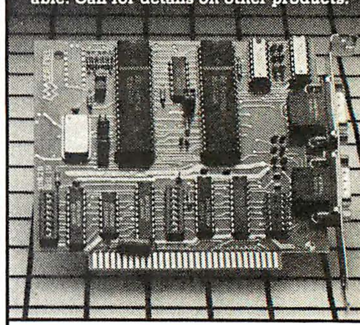
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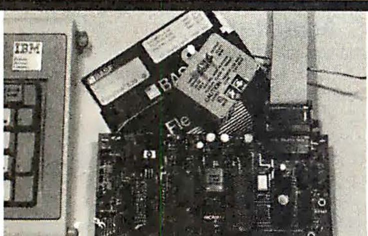
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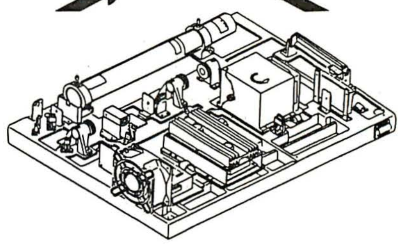
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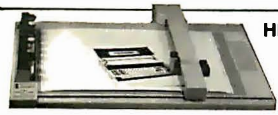
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~~$3495~~

$1595



California Digital has purchased these 20/20 Bernoulli systems from Iomega. The units needed some minor alignment and had to be sent back to Iomega. These have to sold as as reconditioned... but for all practical purpose they are new and come with a **one year Iomega factory warranty.**
The 20/20 Bernoulli Box features removable cartridges, and delivers reliability, expandability, transportability, security and speed in one versatile subsystem. It lets you transfer megabytes of information safely and swiftly for primary or backup storage. Or combine several software programs onto a single cartridge for easy switching from one to another.
Reliable... the Box has incredible resistance to shock and vibration completely eliminating the possility of head crash.
security essential? Don't lock up your system... just lock up the cartridges.

20+20 Subsystem... **$1595;** Non bootable controller... **$159;**
Bootable controller... **$189;** 20 Megabyte Cartridges...



$35

We have them again... The Remex 480 was a sell out two years ago but we located an additional 10,000 units and are offering these 2/3 height IBM/PC compatible 360K/Byte drives at only $35 each at quantity two.

	One	Two	Ten
REMEX 480 ⅔ height for PC	39	35	29
TANDON 65L/2 360K, ½ ht.	79	75	72
TANDON 101/4 full ht. 96TPI.	119	109	99
FUJITSU 5¼" half height	95	89	82
MITSUBISHI new 501 half ht.	119	109	105
MITSUBISHI 504A AT comp.	149	139	135
TEAC FD55BV half height	109	99	89
TEAC FD55FV 96 TPI, half ht.	119	109	105
TEAC FD55GF for IBM AT	149	139	135
PANASONIC 455 Half Height	109	99	89
PANASONIC 475 1.2 Meg./96	119	115	109
Switching power supply			49
Dual enclosure for 5¼" drives			59
3½" DISK DRIVES			
SONY MP-53W 720K/Byte	139	129	123
SONY MP-73W, 2 Meg.	179	169	call
TEAC 35F 720 K/Byte	129	119	115
TEAC 35X, 2 Meg.	call	—	—
5¼" form factor kit			20



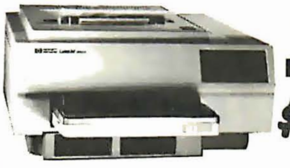
$2495

80 Character Daisy Wheel Printer $759

These Fujitsu Daisy Max 830 were manufactured for Motorola's Computer Division. The purchase order was canceled and Fujitsu was forced to liquidate these 80 character per second daisy wheel printers at "fire sale" prices.
Features: bullet proof construction, your choice of either Centronics parellel or RS-232 serial interface, Diablo 630 wheels and commands, programmable line spacing in increments of 1/96" and column spacing of 1/120". The printer is also capable of underscoring, bold overprint, shadow print, centers and justifies along with vector plotting.
Factory suggested price of the Daisy Max 830 was $2495, California Digital is offering this liquidated special at only $759. Tractor and sheet feeders available.

PRINTERS

IBM Thermal printer, 80 col., serial	$39
Fujitsu D830 80 cps., daisy wheel	759
Silver Reed EXP-800 136 col., 40cps.	729
Juki 6300 daisy wheel 40cps.	819
NEC 8850 Spinwriter daisy wheel 55 cps.	1159
NEC P6/660P 10" 216 cps. NLQ.	469
NEC P7/760P 15" 216 cps. NLQ.	659
Olympia NP80, 200 cps draft, 40nlq.	329
Olympia NP136, 15" same as above	459
Epson FX86E NLQ 10" 240 char/sec.	399
Epson FX286E NLQ 15" 240 char/sec.	539
Epson EX1000 300cps, NLQ/54 cps.	599
Citzen MSP-10 160cps. 10"	299
Citzen MSP-15 160cps. 15"	449
Okidata 182 80 column, par'l.	239
Okidata 192+ 136 column, par'l.	345
Okidata 292 136 column, parellel.	469
Panasonic P1080/I, 10" 120 cps.	229
Panasonic P1091/I, 10" 160 cps.	299
Panasonic P1592 15" 180 cps.	429
Star Gemini NX10, 120 cps 10" NLQ.	239
Star Gemini NX15, 120 cps 15" NLQ.	359
Toshiba 321, 24 wire head 216 cps; NLQ.	519
Toshiba 341, 24 wire head 216 cps. 15".	629
Printronics P300 dot matrix, 300 LPM	3995
Printronics P600 dot matrix, 600 LPM	5795
LASER PRINTERS	
Apple Laser Writer Plus; Postscript	4295
QMS PS/800 2 meg. Postscript. 8 pgs.	4295
Hewlett Packard Series II, laser printer	1795
Texas Instr. OmniLaser 2108 P/S, 8 pgs.	4295
Texas Inst. OmniLaser 2115 P/S, 15pgs	5595
Quadram Quad/Laser, 5 Megabytes	2995



HEWLETT PACKARD

LASER JET II $1795

Standard features of the new Hewlett Packard Series II Laser printer: 512 K byte memory expandable to 4 Megabytes, both serial and parallel ports. List price $2495 California Digital price $1795. Memory upgrade, type fonts and toner cartridges available.

Other Laser Printers available:
Texas Instruments ● Okidata ● Apple ● Ricoh
Qume ● AST Research ● QMS ● Xerox ● Canon
Quadram ● Centronics ● CIE C.Itoh ● DataProducts



$495 DEC/TS03 Tape Drive

Manufactured by Kennedy Magnetics for Digital Equipment. Kennedy Model 9700 features BPI, 12.5 IPS, nine track with seven inch reels. Original price over $3000.
Other tape drives available: Pertec ● Wangco ● Perkin Elmer.

U.S. Robotics 2400 $189



The US Robotics Micro 2400 modem is one hundred percent Hayes compatible, auto dial, auto answer, auto everthing, loudspeaker included. A super value at only $189.

Smarteam 2400 $259



The Smarteam 2400 offers all the features of the Hayes Smart Modem 2400 for a fraction of the price. Now is your opportunity to purchase a 2400 baud modem for only $259.
Also available: The Smarteam 1200 at only $119

MODEMS	
Avatex 1200 baud external, Hayes	99
Hayes Smartmodem 2400 baud modem	529
Smarteam 2400 Hayes Compatible	259
Team 1200 Hayes Compatible, 300/1200	119
Smarteam 1200B IBM 1200 baud card	119
UltraLink 1200 data and voice, Bell202	99
Prometheus 1200 super features	289
Prometheus 1200B internal PC	199
Signalman Mark VI, 300 baud internal PC	35

18 Character Daisy Wheel Printer $99



The Alphacom Daisy Wheel Printer was an excellent value at $495, but we have been asked to assist in liquidating the remaining inventory at only $99. The AlphaCom prints at 18 character per second, is 630 compatible, accepts Diablo daisy wheels and ribbons. Personality modules additional.

NOW YOUR COMPUTER CAN READ!!

Omni-Reader... the first optical character reader **designed and priced for the small computer**

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Uses a standard RS-232 serial port hookup to interface easily with your computer.

21 Megabyte Gold Card $459



Also available 31 Megabytes at only $559.

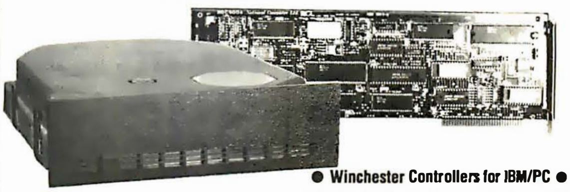
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Seagate $359

30 MEGABYTE WINCHESTER HARD DISK KIT

20 Megabyte Kit $319



Five Inch Winchester Disk Drives

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SEAGATE 238 30 Meg. RLL	299	289
SEAGATE 4026 26 M. 35mS.	559	539
SEAGATE 4051 51 M. 35mS.	695	659
SEAGATE 4096 96 M. 35mS.	859	829
MINISCRIBE 3425 25 m 85ms.	279	247
MINISCRIBE 3650 50 m 61 ms.	419	399
FUJITSU 2242 55 M. 35mS.	1299	1229
FUJITSU 2243 86 M. 35mS.	1695	1619
RODIME RO-204E 53 Meg.	995	959
CONTROL DATA 94155-86 M.	1829	1779
MAXTOR XT1140 140 Meg.	2595	2529
TOSHIBA MK56 70 M. 30mS.	1789	1729

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XEBEC 1220 with floppy controller	189
DTC 5150CX	119
OMTI 5520 half card	99
OMTI 5527 RLL controller	129
ADAPTEC 2070 RLL controller	179
ADAPTEC 2010A	159
WESTERN DIGITAL WD/1002WX2	89
● SCSI/SASI Winchester Controllers ●	
XEBEC 1410A 5¼" foot print	219
WESTERN DIGITAL 1002-05E 5¼"	289
OMTI 20L	89
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Enhanced 5251/11 ... CALL
New! AST PS/2 Add-in Cards ... CALL
Six Pack Premium/XT 256K to 1Mb ... CALL
Advantage Premium/AT EMS 512K ... CALL
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IBM

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80287-6 ... 165.00
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80287-10 ... 449.00
80387 ... 499.00

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Persyst EG-8 EGA Card ... 99.00
Persyst Mono or Color Combo ... 99.95

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Liberty 2Mb ... 399.95
Quadsprint PC/XT Accellerator ... 149.95
Quad EMS I/O • 256K ... 339.00

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GENOA Super EGA ... 299.00
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• Mono/Color Combo Card ... 69.95
VIDEO 7 Vega Deluxe ... 299.00

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14" EGA Monitor w/tilt 'n swivel *plus* Genoa Compatible Super EGA Card **$499.**

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NEC — 2 Yr. Warranty
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SONY
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RGB Monitor w/TV ... SALE

TAXAN
Supervision 650 12" RGB ... CALL
Supervision 660 12" EGA ... 488.00
Supervision 840 16" Ultra Hi Res ... CALL

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LTI Enhanced CGA 14" ... 288
Zenith CGA Color ... 199
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MODEMS

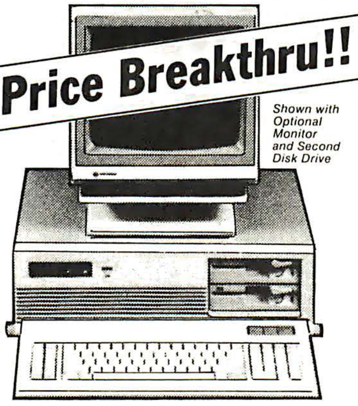
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1200 RS-232 External ... $299.00
1200B w/SMARTCOM (int.) ... 299.00
2400 RS-232 External ... 447.00
2400 w/SMARTCOM II (int.) ... 447.00

MIGENT — 1 Yr. Warr.
Pocket Modem 1200B w/software ... $159.00

EVEREX
Evercom II 1200 Baud Modem (int.) ... $109.00
Evercom II 2400 Baud Modem (int.) ... 179.00

CTS
CTS 2400 Baud (int.) ... $179.00

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w/40Mb (39ms) ... 1549.
w/60Mb (28ms) ... 1949.
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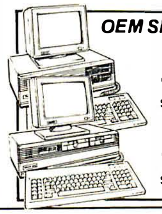
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30Mb PC/XT SPECIAL RLL Upgrade Kit
Okidata 5026 Disk Drive
Western Digital RLL
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2.4576 MHz	2.25	13.000 MHz	2.25
3.000 MHz	2.25	15.000 MHz	2.25
3.2768 MHz	2.25	16.000 MHz	2.25
3.579 MHz	2.25	18.000 MHz	2.25
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4011	.19	4050	.29
4012	.25	4051	.69
4013	.35	4052	.69
4015	.29	4053	.69
4016	.29	4060	.69
4017	.49	4066	.29
4018	.69	4069	.19
4020	.59	4070	.29
4021	.69	4081	.22
4023	.25	4093	.49
4024	.49	14411	9.95
4025	.25	14433	14.95
4027	.39	14497	6.95
4028	.65	4503	.49
4040	.69	4511	.69
4042	.59	4518	.85
4044	.69	4528	.79
4046	.69	4538	.95
4047	.69	4702	12.95

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74HC00		74HCT00	
74HC00	.21	74HCT00	.25
74HC02	.21	74HCT02	.25
74HC04	.25	74HCT04	.27
74HC08	.25	74HCT08	.25
74HC14	.35	74HCT32	.27
74HC32	.35	74HCT74	.45
74HC74	.35	74HCT138	.55
74HC86	.45	74HCT161	.79
74HC138	.45	74HCT240	.89
74HC139	.4	74HCT244	.89
74HC151	.59	74HCT245	.99
74HC154	1.09	74HCT273	.99
74HC157	.55	74HCT373	.99
74HC244	.85	74HCT374	.99
74HC245	.85	74HCT393	.99
74HC273	.69	74HCT4017	1.19
74HC373	.69	74HCT4040	.99
74HC374	.69	74HCT4060	1.49

74LS00

74LS00	.16	74LS112	.29	74LS241	.69
74LS01	.18	74LS122	.45	74LS242	.69
74LS02	.17	74LS123	.49	74LS243	.69
74LS03	.18	74LS124	2.75	74LS244	.69
74LS04	.16	74LS125	.39	74LS245	.79
74LS05	.18	74LS126	.39	74LS251	.49
74LS08	.18	74LS132	.39	74LS253	.49
74LS09	.18	74LS133	.49	74LS257	.39
74LS10	.16	74LS136	.39	74LS258	.49
74LS11	.22	74LS138	.39	74LS259	1.29
74LS12	.22	74LS139	.39	74LS260	.49
74LS13	.26	74LS145	.99	74LS266	.39
74LS14	.39	74LS147	.99	74LS273	.79
74LS15	.26	74LS148	.99	74LS279	.39
74LS20	.17	74LS151	.39	74LS280	1.98
74LS21	.22	74LS153	.39	74LS283	.59
74LS22	.22	74LS154	1.49	74LS290	.89
74LS27	.23	74LS155	.59	74LS293	.89
74LS28	.26	74LS156	.49	74LS299	1.49
74LS30	.17	74LS157	.35	74LS322	3.95
74LS32	.18	74LS158	.29	74LS323	2.49
74LS33	.28	74LS160	.29	74LS365	.39
74LS37	.26	74LS161	.39	74LS367	.39
74LS38	.26	74LS162	.49	74LS368	.39
74LS42	.39	74LS163	.39	74LS373	.79
74LS47	.75	74LS164	.49	74LS374	.79
74LS48	.85	74LS165	.65	74LS375	.95
74LS51	.17	74LS166	.95	74LS377	.79
74LS73	.29	74LS169	.95	74LS390	1.19
74LS74	.24	74LS173	.49	74LS393	.79
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7407	.29
7408	.24
7410	.19
7411	.25
7414	.49
7416	.25
7417	.25
7420	.19
7430	.19
7432	.29
7438	.29
7442	.49
7445	.69
7447	.89
7473	.34
7474	.33
7475	.45
7476	.35
7483	.50
7485	.59
7486	.35
7489	2.15
7490	.39
7493	.35
74121	.29
74123	.49
74125	.45
74150	1.35
74151	.55
74153	.55
74154	1.49
74157	.55
74159	1.65
74161	.69
74164	.85
74166	1.00
74175	.89
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LM317T	.69	LM1488	.49
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6821	1.25
6840	3.95
6843	4.95
6844	6.95
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6847	4.75
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2.0 MHz

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68B02	3.95
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6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

74F00

74F00	.35
74F02	.35
74F04	.35
74F08	.35
74F10	.35
74F32	.35
74F64	.55
74F74	.39
74F86	.55
74F138	.79
74F139	.79
74F253	.89
74F157	1.69
74F240	3.29

74S00

74S00	.29	74S163	1.29
74S02	.29	74S175	.79
74S04	.29	74S195	1.49
74S08	.35	74S240	1.49
74S10	.29	74S241	1.49
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22	15V	.99	4.7	35V	.39
.22	35V	.15	10	35V	.69

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22	50V	.05	.001μf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

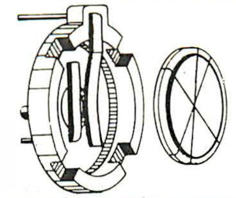
.01μf	50V	.14	.1μf	50V	.18
.047μf	50V	.15	.47μf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1μf	25V	.14	1μf	50V	.14
2.2	35V	.11	10	50V	.16
4.7	50V	.11	22	16V	.14
10	50V	.11	47	50V	.19
47	35V	.13	100	35V	.19
100	16V	.15	220	25V	.25
220	35V	.20	470	50V	.29
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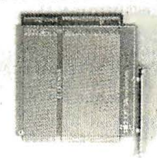
SIP	10 PIN	9 RESISTOR	.69
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EPROM ERASERS

SPECTRONICS CORPORATION

Model	Timer	Chip Capacity	Intensity (uW/Cm²)	Unit Cost
PE-140	NO	9	8,000	$89
PE-140T	YES	9	8,000	$139
PE-240T	YES	12	9,600	$189

DATARASE $34.95

- ERASES 2 EPROMS IN 10 MINUTES TIME
- VERY COMPACT—NO DRAWER
- THIN METAL SHUTTER PREVENTS UV LIGHT FROM ESCAPING

SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
BCD OUTPUT 10 POS. 6 PIN DIP		1.95

DIP SWITCHES

4 position	.85	7 position	.95
5 position	.90	8 position	.95
6 position	.90	10 position	1.29

D-SUBMINIATURE CONNECTORS

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.69	1.35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	---	.79	2.27	---
	FEMALE	DBxxSR	.55	.75	---	.85	2.49	---
WIREWRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	1.39	1.99	---	2.25	4.25	---
	FEMALE	IDBxxS	1.45	2.05	---	2.35	4.49	---
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	---	---
	GREY	HOODxx	.39	.39	---	.39	.69	.75

ORDERING INSTRUCTIONS:
INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED. EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE 59¢

LIGHT EMITTING DIODES

LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
TIL-313	COM CATHODE	.3"	.45
TIL-311	4x7 HEX W/LOGIC	.270"	10.95

DIFFUSED LEDs

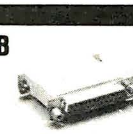
		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

"SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE LEAD	1.49
2x40	2 STRAIGHT LEADS	2.49
2x40	2 RIGHT ANGLE LEADS	2.99

25 PIN D-SUB GENDER CHANGERS $7.95



DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
TOOLED SOLDERTAIL IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
TOOLED WIREWRAP IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	.95	.49	.59	1.29	1.49	---	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS, ABOVE

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.55	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

MUFFIN FANS

3.15" Sq. $14.95 3.63" Sq. $14.95
3.18" Square $16.95

LINE CORDS

2 conductor 39¢ 3 conductor 99¢
3 conductor w/female socket $1.49

CALL FOR VOLUME QUOTES

4164 150ns $1.29   41256 150ns $2.95

MONITOR STANDS

MODEL MS-100 — $12.95
- TILTS & SWIVELS
- STURDY PLASTIC CONSTRUCTION

MODEL MS-200 — $39.95
- TILTS AND SWIVELS
- BUILT-IN SURGE SUPRESSOR
- BUILT-IN POWER STATION INDEPENDENTLY CONTROLS UP TO 5 120 VOLT AC OUTLETS
- UL APPROVED



NASHUA DISKETTES

BOXES OF 10

5¼"	DS/DD 360K	$9.95
5¼"	DS/HD 1.2M	$24.95
3½"	DS/QD 720K	$16.95

5¼" DS/DD SOFT SECTOR
49¢ea BULK QTY 50   **39¢ea** BULK QTY 250

5¼" DISKETTE STORAGE FILE $8.95

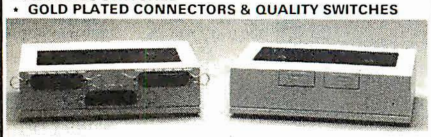
- HOLDS 70 5¼" FLOPPIES
- STURDY, ATTRACTIVE SMOKED ACRYLIC CASE
- COMPLETE WITH HINGED DIVIDERS

VERSION FOR 3½" FLOPPIES AVAILABLE $9.95



2 WAY SWITCH BOXES $39.95

- CONNECT 2 PRINTERS TO 1 COMPUTER OR VICE VERSA
- SERIAL & PARALLEL MODELS AVAILABLE
- ALL LINES SWITCHED
- GOLD PLATED CONNECTORS & QUALITY SWITCHES



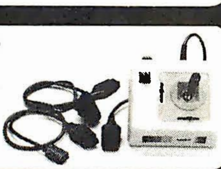
6' INTERFACE CABLES

MEETS FCC REQUIREMENTS 100% SHIELDED

IBM COMPATIBLE PARALLEL PRINTER	$9.95
CENTRONICS (MALE TO FEMALE)	$15.95
CENTRONICS (MALE TO MALE)	$14.95
IBM COMPATIBLE MODEM CABLE	$7.95
RS232 SERIAL (MALE TO FEMALE)	$9.95
RS232 SERIAL (MALE TO MALE)	$9.95
COILED KEYBOARD EXTENDER	$7.95

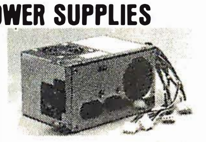
JOYSTICK $19.95

- SET X-Y AXIS FOR AUTO CENTER OR FREE MOVEMENT
- FIRE BUTTON FOR USE WITH GAME SOFTWARE
- INCLUDES ADAPTOR CABLE FOR IBM



SWITCHING POWER SUPPLIES

PS-135 $59.95
- FOR IBM XT COMPATIBLE
- UL APP., 135 WATTS
- +5V/15A, +12V/4.2A -5V/.5A, -12V/.5A
- ONE YEAR WARRANTY



PS-150 *150W MODEL* **$69.95**

PS-200 $89.95
- FOR IBM AT COMPATIBLE
- 200 WATTS
- +5V/22A, +12V/8A -5V/.5A, -12V/.5A
- ONE YEAR WARRANTY

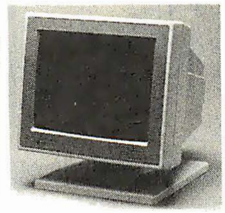


MONITORS

SAMSUNG MONOCHROME

- IBM COMPATIBLE TTL INPUT
- 12" NON-GLARE, LOW DISTORTION, AMBER SCREEN
- RES: 720 x 350
- SWIVEL BASE
- 1 YEAR WARRANTY

$119.95



MULTISYNC *BY NEC* $549.95

- ORIGINAL CGA/EGA/PGA COMPATIBLE MONITOR
- AUTO FREQUENCY ADJUSTMENT
- RESOLUTION AS HIGH AS 800 x 560

EGA *BY CASPER* $399.95

- 15.75/21.85 KHz SCANNING FREQUENCIES
- RES: 640 x 200/350
- .31mm DOT PITCH
- 14" BLACK MATRIX SCREEN
- 16 COLORS FROM 64

RGB *BY CASPER* $279.95

- COLOR/GREEN/AMBER SWITCH
- RES: 640 x 240
- RGB/IBM COMPATIBLE
- 14" NON-GLARE SCREEN
- .39mm DOT PITCH
- CABLE FOR IBM PC INCLUDED

MONOCHROME *BY HYUNDAI* $69.95

- IBM COMPATIBLE TTL INPUT
- 12" NON-GLARE AMBER SCREEN
- ATTRACTIVE CASING WITH A TILT/SWIVEL BASE

TOLL FREE U.S. & CANADA 800-538-5000

20MB HARD DISK ON A CARD



- SAVES SPACE AND REDUCES POWER CONSUMPTION
- IDEAL FOR PCs WITH FULL HEIGHT FLOPPIES
- LEAVES ROOM FOR A HALF LENGTH CARD IN ADJACENT SLOT

$349

RITEMAN II PRINTER



- 160 CPS DRAFT, 32 CPS NLQ MODE
- SUPPORTS EPSON/IBM GRAPHICS
- 9 x 9 DOT MATRIX
- FRICTION AND PIN FEEDS
- VARIABLE LINE SPACING & PITCH

$219.95

IBM COMPATIBLE PRINTER CABLE	$9.95
REPLACEMENT RIBBON CARTRIDGE	$7.95

DISK DRIVES

5¼" SEAGATE HARD DISK DRIVES

ST-225	HALF HEIGHT	20MB	65ms		$259
ST-238	HALF HEIGHT	30MB	65ms	(RLL)	$299
ST-251	HALF HEIGHT	40MB	40ms		$469
ST-277	HALF HEIGHT	60MB	40ms	(RLL)	$649
ST-4038	FULL HEIGHT	30MB	40ms		$559
ST-4096	FULL HEIGHT	80MB	28ms		$895

½ HEIGHT FLOPPY DISK DRIVES

5¼" TEAC FD-55B DS/DD 360K	$109.95
5¼" TEAC FD-55F DS/QUAD 720K	$124.95
5¼" TEAC FD-55GFV DS/HD 1.2M	$154.95
5¼" MITSUBISHI DS/HD 1.2M	$119.95
5¼" DS/DD 360K	$69.95
3½" MITSUBISHI DS/DD (AT OR XT)	$129.95

DISK DRIVE ACCESSORIES

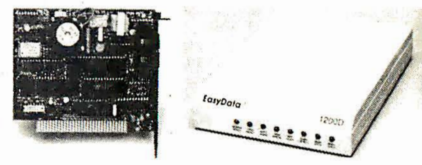
TEAC SPECIFICATION MANUAL	$5.00
TEAC MAINTENANCE MANUAL	$25.00
½ HT MOUNTING HARDWARE FOR IBM	$2.95
MOUNTING RAILS FOR IBM AT	$4.95
"Y" POWER CABLE FOR 5¼" FDDs	$2.95
5¼" FDD POWER CONNECTORS	$1.19

DRIVE ENCLOSURES WITH POWER SUPPLIES

CAB-2SV5	DUAL SLIMLINE FOR 5¼"	$49.95
CAB-1FH5	FULL HEIGHT FOR 5¼"	$69.95
CAB-2SV8	DUAL SLIMLINE FOR 8"	$209.95
CAB-2FH8	DUAL FULL HEIGHT FOR 8"	$219.95

EASYDATA MODEMS

All models feature auto-dial/answer/redial on busy, power up self test, touchtone or pulse dialing, built-in speaker, Hayes and Bell Systems 103 & 212A compatible, full or half duplex, PC Talk III Communications software with internal models and more.



INTERNAL

12H	1200 BAUD ½ CARD	$69.95
24B	2400 BAUD FULL CARD	$179.95

EXTERNAL

(NO SOFTWARE INCLUDED)

12D	1200 BAUD	$119.95
24D	2400 BAUD	$219.95

COMPUTER CASES

Attractive, sturdy steel cases fit the popular sized motherboards and include speakers, faceplates, expansion slots and all necessary hardware.



XT STYLE FLIP-TOP	$34.95
XT STYLE SLIDE-TOP	$39.95
AT STYLE SLIDE-TOP	$89.95

- FRONT PANEL KEYLOCK AND LED INDICATORS

JR. AT STYLE FLIP-TOP $149.95
- INCLUDES 180 WATT POWER SUPPLY
- FRONT PANEL KEYLOCK AND LED INDICATORS

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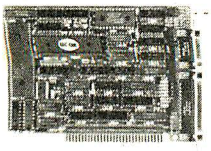
PLEASE USE YOUR CUSTOMER NUMBER WHEN ORDERING

TERMS: Minimum order $10.00. For shipping and handling include $2.50 for UPS Ground and $3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges—please contact our sales department for the amount. CA. residents must include applicable sales tax. All merchandise is warranted for 90 days unless otherwise stated. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale. A full copy of our terms is available upon request. Items pictured may only be representative.

ALL MCT PRODUCTS CARRY A 1 YEAR WARRANTY

INTERFACE CARDS

FROM MODULAR CIRCUIT TECHNOLOGY



MCT-MGP

RUNS COLOR SOFTWARE

DISPLAY CARDS

MCT-MGP MONOCHROME GRAPHICS $59.95
TRUE HERCULES COMPATIBILITY, SUPPORTS LOTUS 123
- SOFTWARE DRIVER ALLOWS COLOR GRAPHICS PROGRAMS TO RUN ON A MONOCHROME MONITOR
- PARALLEL PRINTER PORT

MCT-EGA ENHANCED GRAPHICS ADAPTOR $149.95
100% IBM COMPATIBLE, PASSES IBM EGA DIAGNOSTICS
- 256K OF VIDEO RAM ALLOWS 640 x 350 IN 16 OF 64 COLORS
- COMPATIBLE WITH COLOR AND MONOCHROME ADAPTORS

MCT-CG COLOR GRAPHICS ADAPTOR $49.95
COMPATIBLE WITH IBM COLOR GRAPHICS STANDARDS
- SHORT SLOT SUPPORTS RGB, COLOR & COMPOSITE MONOCHROME
- 640/320 x 200 RESOLUTION, LIGHT PEN INTERFACE

MULTIFUNCTION CARDS

MCT-MF MULTIFUNCTION $79.95
ALL THE FEATURES OF 6 PACK· AT HALF THE PRICE
- 0-384K DYNAMIC RAM USING 4164s
- SERIAL, PARALLEL, GAME PORTS, CLOCK/CALENDAR

MCT-MGMIO MONOGRAPHICS I/O $119.95
TOTAL SYSTEM CONTROL FROM A SINGLE SLOT
- 2 FLOPPY CONT, SERIAL, PARALLEL, GAME PORT, CLOCK/CAL
- RUN COLOR GRAPHICS SOFTWARE ON A MONOCHROME MONITOR

MCT-MIO MULTI I/O FLOPPY $79.95
A PERFECT COMPANION FOR OUR MOTHERBOARDS
- SERIAL, PARALLEL, GAME PORT, CLOCK/CALENDAR
- SUPPORTS UP TO 2 360K FLOPPIES, 720K WITH DOS 3.2

MIO-SERIAL 2nd SERIAL PORT $15.95

MCT-IO MULTI I/O CARD $59.95
USE WITH MCT-FH FOR A MINIMUM OF SLOTS USED
- SERIAL PORT, CLOCK/CALENDAR WITH A BATTERY BACK-UP
- PARALLEL PRINTER PORT ADDRESSABLE AS LPT1 OR LPT2

IO-SERIAL 2nd SERIAL PORT $15.95

MCT-ATMF AT MULTIFUNCTION $139.95
ADDS UP TO 3 MEGABYTES OF RAM TO THE AT
- USER EXPANDABLE TO 1.5 MB OF MEMORY (ZERO K INSTALLED)
- INCLUDES SERIAL PORT AND PARALLEL PORT

ATMF-SERIAL 2nd SERIAL PORT $24.95
MCT-ATMF-MC PIGGYBACK BOARD (NO MEMORY) $29.95

MCT-ATIO AT MULTI I/O $59.95
USE WITH MCT-ATFH FOR A MINIMUM OF SLOTS USED
- SERIAL, PARALLEL AND GAME PORTS
- USES 16450 SERIAL SUPPORT CHIPS FOR HIGH SPEED OPERATION

ATIO-SERIAL 2nd SERIAL PORT $24.95

MEMORY CARDS

MCT-RAM 576K RAM CARD $59.95
A CONTIGUOUS MEMORY SOLUTION IN A SHORT SLOT
- USER SELECTABLE CONFIGURATION AMOUNTS UPTO 576K USING 64K & 256K RAM CHIPS (ZERO K INSTALLED)

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2 MB OF LOTUS/INTEL/MICROSOFT COMPATIBLE MEMORY FOR XT
- CONFORMS TO LOTUS/INTEL EMS
- USER EXPANDABLE TO 2 MB
- EXPANDED/CONVENTIONAL MEMORY, RAMDISK AND SPOOLER

MCT-ATEMS AT VERSION $139.95

DRIVE CONTROLLERS

MCT-FDC FLOPPY DISK CONTROLLER $29.95
QUALITY DESIGN OFFERS 4 FLOPPY CONTROL IN A SINGLE SLOT
- INTERFACES UP TO 4 FDDs TO AN IBM PC OR COMPATIBLE
- SUPPORTS BOTH DS/DD AND DS/QD WITH DOS 3.2

MCT-HDC HARD DISK CONTROLLER $79.95
HD CONTROL FOR WHAT OTHERS CHARGE FOR FLOPPY CONTROL
- SUPPORTS 16 DRIVE SIZES INCLUDING 5, 10, 20, 30 & 40 MB
- DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES

MCT-FDC-1.2 1.2MB FLOPPY CONTROLLER $69.95
ADD VERSATILITY & CAPACITY TO YOUR XT
- SUPPORTS 2 DRIVES, BOTH MAY BE 360K OR 1.2 MEG
- ALLOWS DATA TO FLOW FREELY FROM XTs TO ATs

MCT-FH FLOPPY/HARD CONTROLLER $139.95
SYSTEM STARVED FOR SLOTS? SATISFY IT WITH THIS TIMELY DESIGN
- INTERFACES UP TO 2 FDDs & 2 HDDs, CABLING FOR 2 FDDs & 1 HDD
- SUPPORTS BOTH DS/DD & DS/QD WITH DOS 3.2

MCT-ATFH AT FLOPPY/HARD CONTROLLER $149.95
FLOPPY/HARD DISK CONTROL IN A TRUE AT DESIGN
- SUPPORTS UP TO 2 360K/720K/1.2MB FDDs AS WELL AS 2 HDDs USING STANDARD CONTROL TABLES

Seagate

1/2 HEIGHT HARD DISK DRIVES

40 MB $469
60 MB $649

Drives are Seagate models ST-251 (40 MB) & ST-277 (60 MB RLL) 5 1/4" half heights FAST 40ms access time!

1/2 HT HARD DISK SYSTEMS

20 MB $289
30 MB $329

Systems include Seagate 1/2 height hard drive, drive controller, cables & instructions. All drives are pre-tested & warranted for 1 year.

IBM COMPATIBLE MOTHERBOARDS

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MCT-TURBO TURBO 4.77/8 MHz $109.95
- 4.77 OR 8 MHz OPERATION WITH 8088-2 & OPTIONAL 8087-2 CO-PROCESSOR
- DYNAMICALLY ADJUSTS SPEED FOR MAXIMUM THROUGHPUT & RELIABILITY DURING DISK I/O
- CHOICE OF NORMAL/TURBO MODE OR SOFTWARE SELECT PROCESSOR SPEED

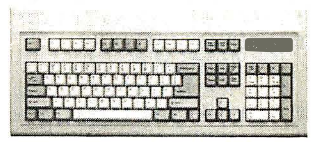
MCT-XTMB STANDARD MOTHERBOARD $97.95

MCT-ATMB 80286 6/8 MHz $379.95
- 8 SLOT (2 EIGHT BIT, 6 SIXTEEN BIT) AT MOTHERBOARD
- HARDWARE SELECTION OF 6 OR 8 MHz
- 1 WAIT STATE
- KEYLOCK SUPPORTED, RESET SWITCH, FRONT PANEL LED INDICATOR
- SOCKETS FOR 1 MB OF RAM AND 80287
- BATTERY BACKED CLOCK

MCT-BATMB MINI 80286 $429.95
- REPLACEMENT BOARD FOR XT STYLE CHASSIS
- OPERATE AT 6/10 MHz WITH UP TO 1MB ON-BOARD MEMORY (ZERO K INSTALLED)
- SOCKET FOR 80287 MATH CO-PORCESSOR
- BATTERY BACKED CLOCK
- 8 SLOTS: 2 EIGHT BIT, 6 SIXTEEN BIT
- USES CHIPS & TECHNOLOGY CHIP SET FOR RELIABILITY AND SMALL SIZE

IBM COMPATIBLE KEYBOARDS

FULL ONE YEAR WARRANTY



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- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- LED INDICATORS
- AUTO REPEAT FEATURE
- SEPARATE CURSOR PAD

MCT-5060 $59.95
- IBM AT STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- LED INDICATORS
- AUTO REPEAT FEATURE

MCT-5150 XT STYLE LAYOUT $49.95
MCT-5151 KB5151™ EQUIV. $69.95

WHY BUY A SYSTEM FROM JDR?

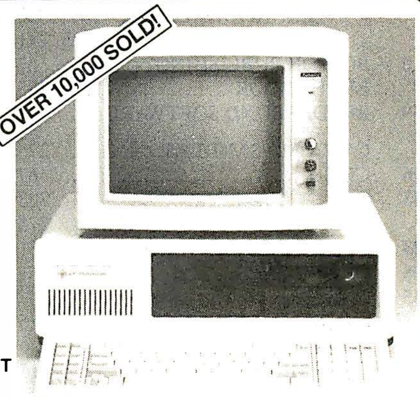
- ★ BUILD IT YOURSELF AND SAVE
- ★ QUALITY COMPONENTS AT COMPETITIVE PRICES
- ★ TOLL FREE TECHNICAL SUPPORT IN THE U.S. AND CANADA
- ★ MONEY BACK GUARANTEE (ASK FOR DETAILS)

Dear Sirs,
My reason for writing is to tell you that in a day and age of excuses, delays, broken promises and a general total lack of interest, it was a real pleasure to have my insignificant order handled in such a professional and pleasant manner.

Gary Reed

BUILD YOUR OWN 256K XT COMPATIBLE

- ★ MOTHERBOARD
- ★ 256K OF MEMORY
- ★ 135 WATT POWER SUPPLY
- ★ FLIP-TOP CASE
- ★ XT STYLE KEYBOARD
- ★ 360K FLOPPY DRIVE
- ★ DRIVE CONTROLLER
- ★ MONOCHROME MONITOR
- ★ GRAPHICS ADAPTOR



FOR ONLY $499.15

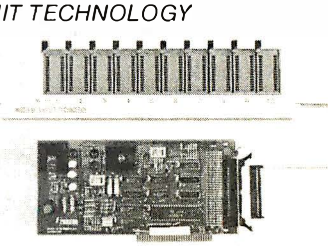
ANYONE CAN BUILD A SYSTEM IN ABOUT 2 HOURS USING A SCREWDRIVER AND OUR EASY-TO-FOLLOW INSTRUCTIONS!

DEVELOPMENT TOOLS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-EPROM PROGRAMMER $129.95
PROGRAMS 27xx & 27xxx EPROMS UP TO 27512
- SUPPORTS VARIOUS PROGRAMMING FORMATS AND VOLTAGES
- SPLIT OR COMBINE CONTENTS OF SEVERAL EPROMS OF DIFFERENT SIZES
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MCT-EPROM-4 4 GANG PROGRAMMER $189.95
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MCT-PAL PAL PROGRAMMER $269.95
MCT-MP PROCESSOR PROG. $199.95



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EDITORIAL INDEX BY COMPANY

Index of companies covered in articles, columns, or news stories in this issue.
Each reference is to the first page of the article or section in which the company name appears.

EDITORIAL INDEX BY COMPANY

COMING UP IN BYTE

Products in Perspective:

Possible Short Takes include The Awesome I/O Card, Full Write Professional, Stata, The Complete Answering Machine, Lahey Personal FORTRAN, Flash-Up Windows, MacScheme + Toolsmith, Toshiba PageLaser 12, TransImage Scanner, FiberOptic LAN, Microsoft Bookshelf, and PC-Elevator 386 Board.

We will have First Impressions on Hypercard for the Macintosh Plus, SE, or II.

Our Group Review and BIX Product Focus will cover high-speed memory boards for the IBM PC AT and compatibles.

System Reviews will look at the following machines: PC's Limited 386, Zenith Z-183 laptop, and Atari ST 4.

Hardware Reviews consider three accelerator boards for the Macintosh Plus and SABA's hand-held document scanner.

For Software Reviews, we have two Pascals for the IBM PC and The Santa Cruz Operation's SCO Xenix.

A roundup of desktop-publishing packages, FastCAD, and Carbon Copy are Application Reviews.

Rounding out this section are Computing at Chaos Manor and Applications Only.

In Depth:

We'll examine natural languages, including a primer, notes on Q&A's design, natural-language interfaces for DOS, a natural-language interface in C, building a brain, and a resource guide of vendors in this field.

Features:

A New Generation piece on the Motorola 68882 and articles on three-dimensional plotting, information theory, an algorithm for mimicking mountains, Chinese computing, and enhancing the stars. Ciarcia's Circuit Cellar is part 2 of the construction of an IC tester.

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March	$4.25		$4.25
April	$4.25		$4.25
May	$4.25		$4.25
June	$4.25	$4.25	$4.25
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TIPS

SUBSCRIBERS ONLY!*

Use BYTE's Telephone Inquiry Processing System

Using TIPS can bring product information as much as 10 days earlier.

SEND FOR YOUR SUBSCRIBER I.D. CARD

1) If you are a new subscriber or have lost your I.D. card, circle #1 on the Reader Service Card; **attach mailer label**. We will immediately send your personal TIPS subscriber card.

GET PREPARED

2) Write your Subscriber Number, as printed on your Subscriber I.D. Card, in boxes in Step 5 below. (Do not add 0's to fill in blank boxes)

3) Write numbers for information desired in boxes in Step 7b below. (Do not add 0's to fill in blank boxes.)

CALL TIPS

4) Now, on a Touch-Tone telephone dial: **(413) 442-2668** and wait for voice commands.

ENTER YOUR SUBSCRIBER AND ISSUE NUMBERS

5) When TIPS says: "Enter Subscriber Number"
(Enter by pushing the numbers and symbols [# or * enclosed in the boxes] on telephone pad ignoring blank boxes)
Enter □ □ □ □ □ □ □ □ □ □ [#] [#]

6) When TIPS says "Enter magazine code & issue code"
Enter [1] [#] [1] [1] [7] [#] [#]

ENTER YOUR INQUIRIES

7a) When TIPS says "Enter (next) Inquiry Number"
Enter one inquiry selection from below (ignore blank boxes)

b) Repeat 7a as needed (maximum 17 inquiry numbers)

1. □ □ □ [#] [#]	6. □ □ □ [#] [#]	10. □ □ □ [#] [#]	14. □ □ □ [#] [#]
2. □ □ □ [#] [#]	7. □ □ □ [#] [#]	11. □ □ □ [#] [#]	15. □ □ □ [#] [#]
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5. □ □ □ [#] [#]			

END SESSION

8) End session by entering [*] [*] [9] [1] [#] [#]

9) Hang up after hearing final message
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Jade Computer Products (U.S. Subscribers)

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FREE Information Retrieval Service

To assist you in making your evaluations, purchasing decisions, or recommendations, you can request further information directly from the manufacturer or service company on products and services advertised in this issue. There is no charge, no obligation. Just complete and mail the attached post-paid, self-addressed reply card, and we'll do the rest.

1 Circle numbers on reply card which correspond to numbers assigned to items of interest to you.

2 Check all the appropriate answers to questions "A" through "F".

3 Print your name and address and mail.

Fill out this coupon carefully. PLEASE PRINT. Requests cannot be honored unless the zip code is included. This card is valid for 6 months from cover date.

A. What is your primary job function? (Check one only)
1 ☐ Business Owner, General Management, Administrative
2 ☐ MIS/DP, Programming
3 ☐ Engineering/Scientific, R&D
4 ☐ Professional (law, medicine, accounting)
5 ☐ Other

B. How many people does your company employ?
1 ☐ 25 or fewer
2 ☐ 26-99
3 ☐ 100-499
4 ☐ 500-999
5 ☐ 1000 or more

C. Reason for request: (Check all that apply).
1 ☐ Business use for yourself
2 ☐ Business use for your company
3 ☐ Personal use

D. Your next step after information is received:
1 ☐ Purchase order
2 ☐ Evaluation
3 ☐ Specification/Recommendation

E. Please indicate the product categories for which you influence the selection or purchase at your (or your client's) company or organization. (Check all that apply).
1 ☐ Microcomputers
2 ☐ Peripherals
3 ☐ Software
4 ☐ Accessories and supplies

F. For how many microcomputers do you influence the purchase of products at your (or your client's) company or organization?
1 ☐ 1 3 ☐ 5-9
2 ☐ 2-4 4 ☐ 10 or more

Name ______________________

Title ______________________

Company ______________________

Address ______________________

City ______________ *State* ______________

Zip ______________ *Telephone* ______________

CIRCLE FOR FREE INFORMATION NOVEMBER 47BRSA

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973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999

Fill out this coupon carefully. PLEASE PRINT. Requests cannot be honored unless the zip code is included. This card is valid for 6 months from cover date.

A. What is your primary job function? (Check one only)
1 ☐ Business Owner, General Management, Administrative
2 ☐ MIS/DP, Programming
3 ☐ Engineering/Scientific, R&D
4 ☐ Professional (law, medicine, accounting)
5 ☐ Other

B. How many people does your company employ?
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Name ______________________

Title ______________________

Company ______________________

Address ______________________

City ______________ *State* ______________

Zip ______________ *Telephone* ______________

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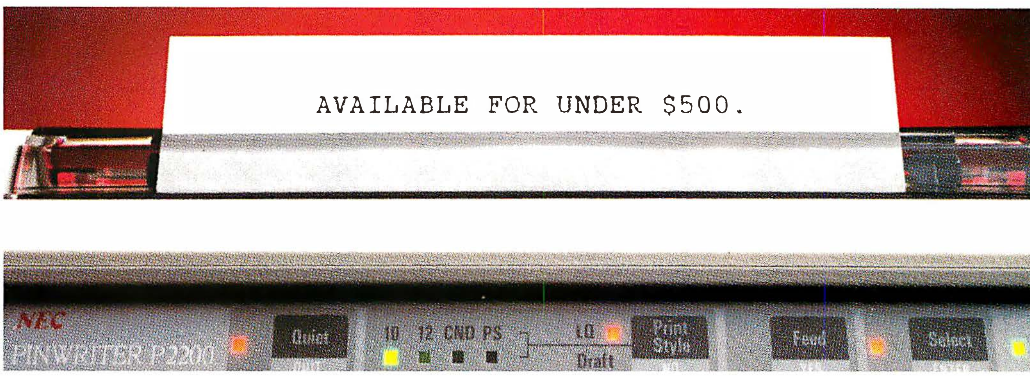
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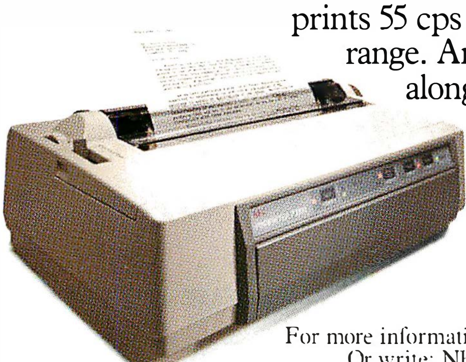
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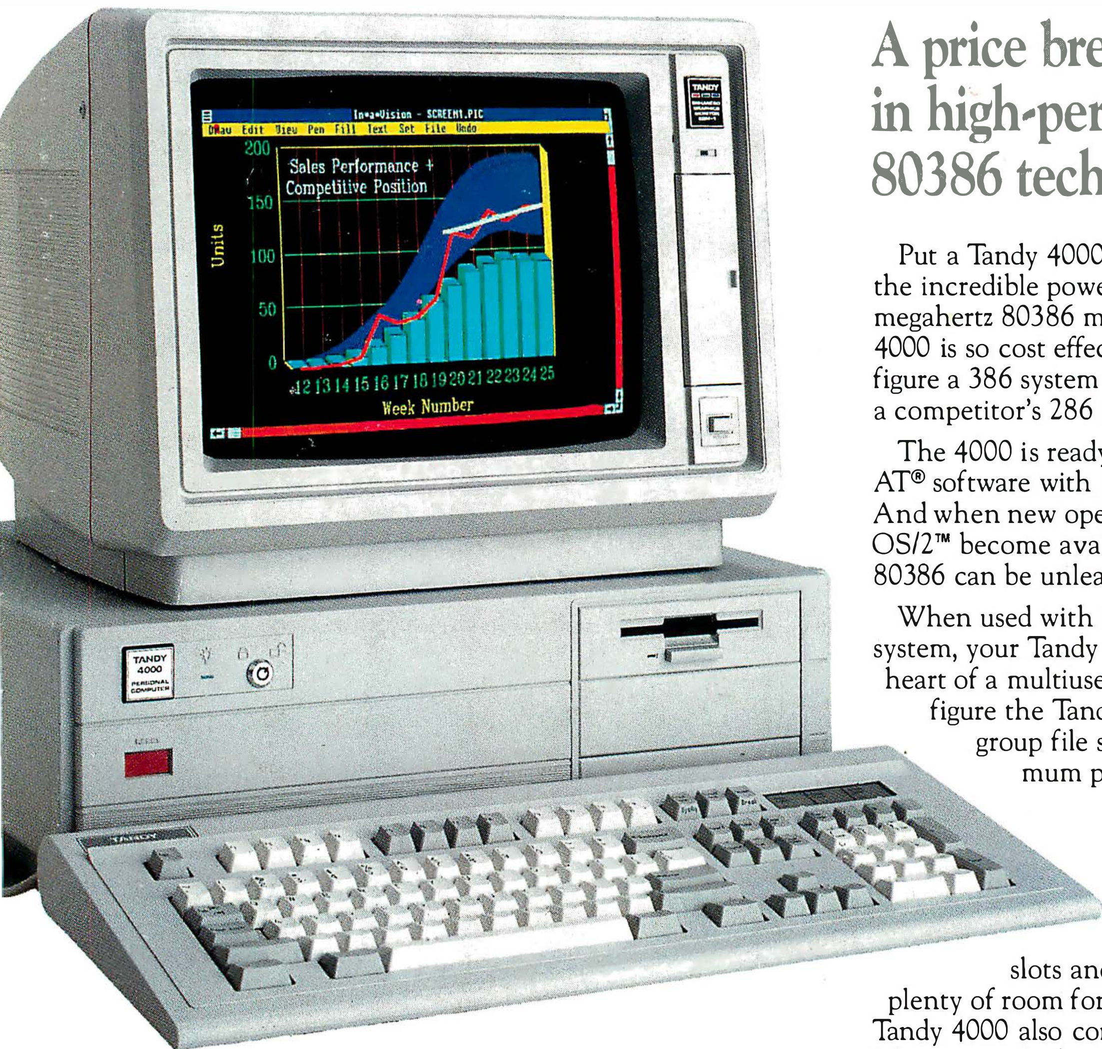
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